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GEOLOGY AND MINERAL RESOURCES OF THE CURWENSVILLE QUADRANGLE

George H. Ashley

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
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GEOLOGY AND MINERAL RESOURCES OF THE CURWENSVILLE QUADRANGLE

by George H. Ashley

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PREFACE

This report presents the results of a survey made in 1903. The subsequent office work revealed evidences of mistakes in correlation that delayed its immediate publication, although the principal findings of the survey were published in several short papers dealing with the structure, coal, clay, oil and gas, and water resources. During the next few years studies in adjoining regions revealed that the type section obtained by the Second Geological Survey of Pennsylvania—which was accepted in the 1903 survey—was subject to great local deviation. To take two examples; in 1903, following the Second Survey, we assumed that the coal beds might thicken and thin or feather out within limits of a few feet. Later it was found that in adjoining areas the Lower Freeport coal is a double bed, that generally only one bed appears, the two benches having coalesced, or one of them being absent, while nearby the two benches are as much as 55 feet apart. Or again, the Second Survey—and we in 1903—assumed that the Lower Productive Coal Measures or Allegheny Group lay on a massive sandstone, the Homewood. But in parts of this quadrangle, as revealed more clearly elsewhere, the Homewood interval is occupied by normal ''coal measures'' with several coal beds and their underlying clays. Thus, later drilling on upper Potts Run revealed that a conglomeratic sandstone supposed to be the Homewood is 417 feet below the Upper Freeport coal instead of the normal about 300 feet, while in the 67 feet immediately overlying are six thin beds of coal. This condition shows clearly on lower Clearfield Creek above Clearfield Junction and around Clearfield. Not anticipating such variations from what had been universally accepted as the normal section, in a region where outcrops are few and far between, the geology was interpreted in the field in accordance with the type section. After it became evident in the office that the local sections are in many places far from normal, it became clear that much of the area would have to be re-examined to determine in what areas the section is not normal and if possible to reinterpret the geology.

But in the meanwhile the writer became absorbed in administrative work and Mr. Clapp had entered private geologic work. As the years have slipped by without the necessary opportunity for such a revision presenting itself, it has seemed best to publish the material on hand as it is, in the hope that with this material before them others can make such readjustments as are necessary.

Later data from several sources have been woven into the report though their location and interpretation are usually not as accurate as that originally collected. However, owing to the closing of mines, much of the data here presented are not now easily available. While, in general, the better and more easily accessible deposits have been mined out, the survey shows a large volume of thin, but minable, coal which will be mined some day.

GEOLOGY AND MINERAL RESOURCES OF THE CURWENSVILLE QUADRANGLE

By George H. Ashley

Geology by Geo. H. Ashley and Frederick G. Clapp
(Including notes by J. H. Hance, F. T. Moyer and R. W. Stone)

GENERAL GEOGRAPHY AND GEOLOGY

Position and Interest

The Curwensville quadrangle is in Clearfield County just west of the center of Pennsylvania. This report presents maps and descriptions of the surface features, geology, and mineral resources of the quadrangle, see Fig. 1, which lies between parallels 40° 45′ and 41° 0′ north and meridians 78° 30′ and 78° 45′ west, covering an area about 17½ miles from north to south and 13½ miles from east to west, an area of 225.90 square miles. The quadrangle is entirely within the bituminous coal field. The rocks consist of sandstones, shales, coal beds, clays, and limestones, making up the lower part of the "Coal

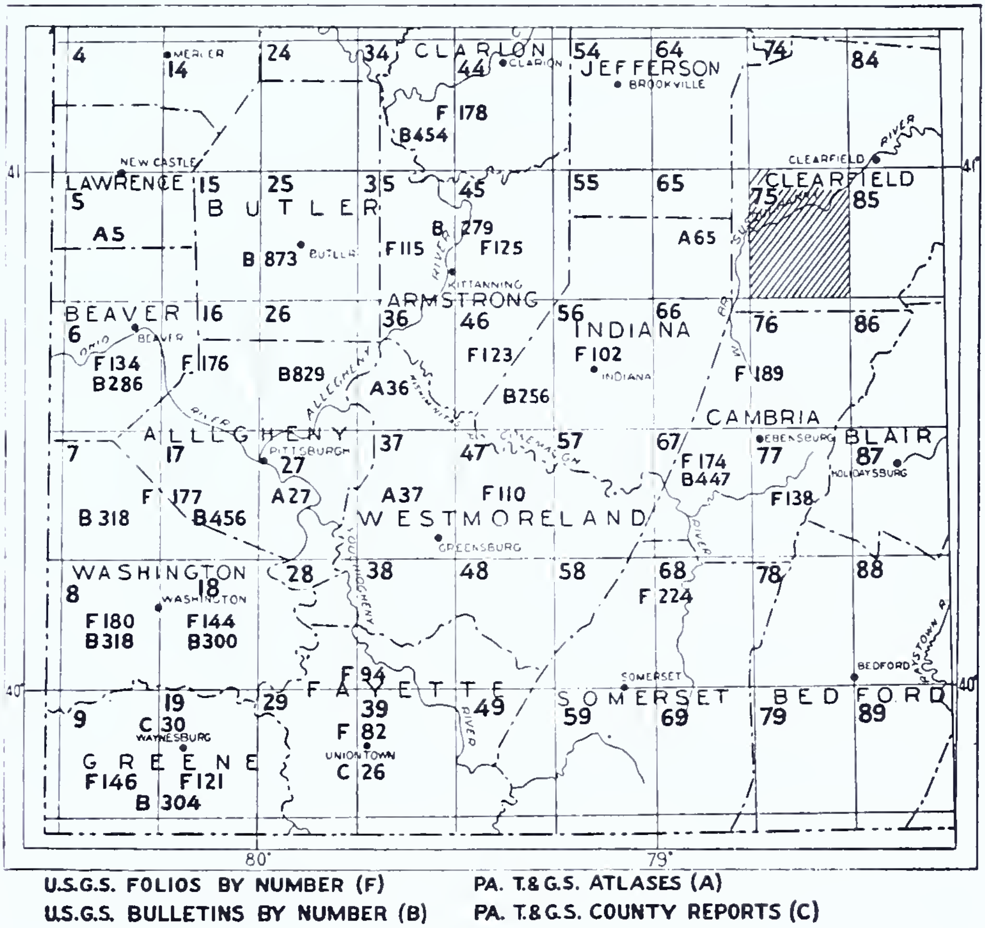

Figure 1. Sketch showing location of Curwensville quadrangle.

Measures'' of western Pennsylvania, including the Freeport, Kittanning, Clarion, Brookville, and Mercer coals, clays, limestones, and associated rocks. The area is of economic interest because of covering the Grampian, Coalport, and other small coal-mining centers, some of the flint clay area of Clearfield County, and part of the Curwensville building-stone district. Surrounding these developed tracts are large areas of undeveloped coal and other resources.

Mineral resources

For three-fourths of a century, the name Clearfield has stood for a bituminous or ''semi-bituminous'' coal of very high grade. The original ''Clearfield coal'' came from a small basin in Clearfield County extending from Morrisdale and beyond, past Philipsburg and Osceola to Houtzdale and beyond to the west and southwest. The basin is traversed by Moshannon Creek and the term Moshannon coal was early used as synonymous with Clearfield coal. Later Moshannon coal was applied in particular to the coal from the Lower Freeport bed (Moshannon bed) which has long been mined out. Closely similar coal is still being shipped from other beds, both from the original basin as limited above and from other areas nearby.

In his report on this basin in 1874, Mr. Franklin Platt had this to say of the coal in this basin.[1]

> "The coal shipped east to market from the Clearfield steam coal basin is widely and favorably known and there is already an extended and growing demand for the coal on account of its high steam generating power and its value in working iron. Besides supplying large quantities of iron and steel works on the Susquehanna and Schuylkill, much coal reaches tide level at Greenwich Point and Amboy. Some idea of the stability of the trade and its growing hold upon the market may be inferred from the fact that in 1874, a year of almost unparalleled business depression. the shipment of Clearfield coal amounted to 658,315 tons. In 1873 it was 620,300 tons, showing a gain of 38,000 tons in 1874. The basin is well located, geographically; the coal lies favorable for economic mining, and the production can at any time be largely and suddenly increased to supply any extra demand."
>
> "Though with only some ten years of reputation upon them, these coals now rank in the market with the best known and esteemed iron and steam coals; and the analyses given in the body of this report, with the description of the mines shows the average excellent character of the coal. both from the mines working coal bed 'B' and those working coal bed 'D.'"
>
> "It may be noted here that these coals are frequently, perhaps usually, termed semi-bituminous coals. They are truly bituminous, having over 20 percent of volatile matter on the average, while the term semi-bituminous belongs to the Cumberland, Towanda, Blossburg, etc., coals, which average between 15 and 20 percent of volatile matter."

The area contains 15 or more coal beds, of which four are quite widely workable; as many more can be mined locally, and the others are thin or minable only in pockets or in the distant future. The workable beds are from 3 to 6 feet thick; but in other areas the same beds are too thin to be mined with profit. Most of the beds contain thin partings or binders of clay or shale, or benches of bone or bony coal and are overlain by shale and underlain practically everywhere by clay. The coal is chemically a ''medium volatile'' coal verging toward "low volatile," averaging on the as-received basis 65 percent or more of fixed carbon, 25 percent or less of volatile matter, about 3 percent of moisture before air-drying, 4 to 9 percent of ash, and 0.6 to 2.5 percent of sulphur.

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[1] Second Geol Survey of Pa., Rept. H., 1875, p. 61.

Some or all of the coal may be of high-grade coking quality, judging by extensive coking formerly carried on in the Punxsutawney district only a short distance to the west. In 1904 there were in that district 657 ovens in a single bank at Walston, extending over a length of nearly 1¼ miles, and 516 ovens in two banks at Adrian.

None of the mines at present operating is large. From its position, well to the northeast of the Pittsburgh, Ohio, and West Virginia fields, this field is advantageously situated to serve New York City or State and the New England States. It is to this market that this coal mainly goes.

As a steam coal, Clearfield coal is considered the peer of any of the bituminous coals of the United States. The coal in this region increases in fixed carbon from west to east, the highest percentage of fixed carbon occurring in the original Moshannon basin. The coal beds are shallow, none being over 1,000 feet deep and, as a rule, they are less than 400 feet deep. Over part of the area some or all of the coals have been removed by erosion.

The clay rocks of this area consist of: 1. Underclays from one or two to 18 feet thick, averaging from 2 to 4 feet thick, and having the usual characteristics of Coal Measure clays. They underlie each of the coals, and are used for brick and tile or for mixing with the flint clay. 2. Flint clays, generally associated with the underclays, and possibly a modification of them, are valuable for making fire brick. These are of variable character, but some very high grade clay is found in the district which is thought to be at the horizon of the Mount Savage clay of Maryland. Flint clays of unknown quality and thickness crop out in many parts of the quadrangle. 3. Shales from which paving brick and tile can be made. The shales in the area are usually sandy, which may affect their use for paving brick or tile.

Sandstone is abundant over parts of the county, being extensively quarried around Curwensville and to a smaller extent elsewhere. The stone of this area is well suited for rough structural work, and has been, and is being used largely for bridges, and has been used locally for buildings. Stone for the Pennsylvania Railroad stone-arch bridge across the Susquehanna at Rockville above Harrisburg and part of the stone for the Market Street bridge at Harrisburg, came from this area.

The limestone resources of the region consist of a few beds, usually thin and impure, well suited for burning for agricultural uses, but having little value for chemical lime, fluxing, or structural uses.

The area is all well watered except as mining operations may have drained the surface. Artesian water should be found in the synclines. The main streams present a few possibilities of low-head water power developments, but in most instances an auxiliary steam plant would be needed to maintain a high duty in dry weather. Large power developments could be made at several points were it not for the occupancy of the valleys by railroads and towns, of greater value than the water power to be derived by flooding the valleys.

Agriculturally, the region is not rich, though many of the rolling uplands and some of the valleys appear to yield fair crops. The sandstones and sandy shales of the area do not appear to contain a large amount of plant food and large parts of the region are steep and covered with sandstone debris.

Previous geologic work

Probably one of the first notices of the geology in this immediate region appeared in Featherstonhaugh's Monthly American Journal of Geology and Natural History, for April, 1832, in an article on "Section of the Allegheny Mountains and the Moshannon Valley in Centre County, Pennsylvania", by R. C. Taylor. During the first official geologic survey of Pennsylvania under H. D. Rogers, this region was visited in 1838 by Charles E. Trego and Townsend Ward who "wandered through the wilderness south of the Clearfield turnpike as far as the Maryland line (keeping east of Chestnut Ridge), to get some general idea of its geology".[2] Not much of the work appears to have been in the Curwensville quadrangle. Two years later, in 1840, the work was taken up again in this area by James T. Hodge, assisted by Townsend Ward and after July by Mr. Lesley; with the "aid of a party of assistants and miners, provided with tents and other equipment essential to an uninterrupted residence in the woods". Mr. Lesley, in describing the work later, says that the party had two tents, wagon and three horses, and employed three brothers as miners, in addition to the cook. The party was in camp for seven months, moving every week or 10 days, and was not broken up until there was a foot of snow on the ground. Mr. Rogers says of the type of work done during that year, "By this combination of scientific research with practical exploration, the true position of nearly every mineral band in the district has been established and the number, thickness, quality and distance apart of the various beds definitely ascertained in numerous localities, so as to afford a clue to the mineral resources of every important neighborhood in the several basins comprised within the region.[3]"

It seems that even at this early date, mining was being carried on near Philipsburg; Rogers' 5th Annual Report gives sections of the coals near Philipsburg, on Clearfield Creek near Blaine Run; on the John Goss place 5 miles west-southwest of Philipsburg; on the Gearhart farm, 1½ miles southwest of Philipsburg; on Coal Hill between Cold Spring and Trout Runs; on the east fork of the west branch of Muddy Run near the south county line, as well as analyses of these coals and of some iron ores in this region. The coal analyses gave only the volatile matter and coke, it not being appreciated at that date that the percentage of sulphur, phosphorus and other minor elements was of the utmost importance commercially.

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[2] Lesley, J. P., Historical sketch of geological explorations: Pa. 2d Geol. Survey, Rept. A., p. 69, 1876.

[3] Rogers, H. D., 5th Annual Report of the State Geologist of Pennsylvania, 1841.

On the organization of the Second Geological Survey of Pennsylvania in 1874, one of the limited number of districts to be surveyed that first year was the bituminous coal region of Clearfield and Jefferson counties. The work was in charge of Franklin Platt, assisted by R. H. Sanders, H. J. Fagen, and C. A. Young. July and August were spent in Clearfield and Centre Counties. In accordance with the plan of work adopted by the Second Geological Survey, an instrumental stadia line was run by the aids while Mr. Platt devoted himself to the geology, mines, etc. On account of the large area covered, it is evident that the work could be little better than a reconnaissance and while many facts were recorded, naturally many mistakes of correlation were made. In 1883, H. M. Chance revised the geology of Clearfield County. These reports were designated H, H6, and H7, respectively. At the time of the Platt survey in 1883, this region was fairly well supplied with railroads and through the Moshannon Creek basin an abundance of mines sent out a large amount of coal. Indeed, the opportunity at that time to examine the coal was probably as good, and possibly better than during the survey of 1903. The continuance of mining has shown some discrepancies in the correlations as made in 1883, but the change in the results between them and 1903 is largely due to the fact that in the meantime mining has extended over a much larger territory, and the more recent work was done on the basis of an up-to-date topographic map. The report of Mr. Chance in 1883 is accompanied with a map on the scale of 2 miles equal one inch, and by a sketch map of the Houtzdale-Philipsburg region on the scale of 3,200 feet equal one inch.

Recent geologic work

The topographic atlas sheet forming the base map of this area was surveyed in 1902, the topography being by Frank Sutton, J. D. Forster and J. B. Daingerfield. The geologic field work for this report was done in 1903, July to October, by Frederick G. Clapp and the writer. In preparing the report, several problems developed, which later work in adjoining quadrangles revealed as due to our having followed the same conclusions as the Second Survey, later found to be in error. (The Second Survey assumed that the Allegheny formation lay between two massive sandstones, the Mahoning above and the Homewood below. Later, it was found that in part of this region, as in some others, the Lower Mahoning sandstone space for a thickness of 70 feet is all shale, and that a massive sandstone supposed to be the Homewood and below the Brookville coal is really above that coal and actually the Clarion sandstone.) These and other related problems delayed immediate publication of the report. Then the writer's duties became largely administrative, preventing consecutive work on this area. In subsequent years the writer had opportunity to cross the area several times, noting changes in mining operations, the last time in the summer of 1938. No detailed restudy was made of any part of the area.

In 1913, J. H. Hance, in connection with studies of the fire clays of Clearfield County, made a few notes on this area. In 1924, R. W. Stone visited new mines along the river from Curwensville to Bells

Landing. In 1930, F. T. Moyer spent three days examining developments along the eastern edge of the quadrangle.

General relations of Appalachian region

Some of the features of this immediate area are better understood in the light of a broad knowledge of the geology of the province of which it is a part. The Appalachian region consists of four provinces. The plateaus on the west, the valley in the center, the mountains east of that, and the Piedmont between the mountains and the Coastal Plain, as suggested in Figure 2.

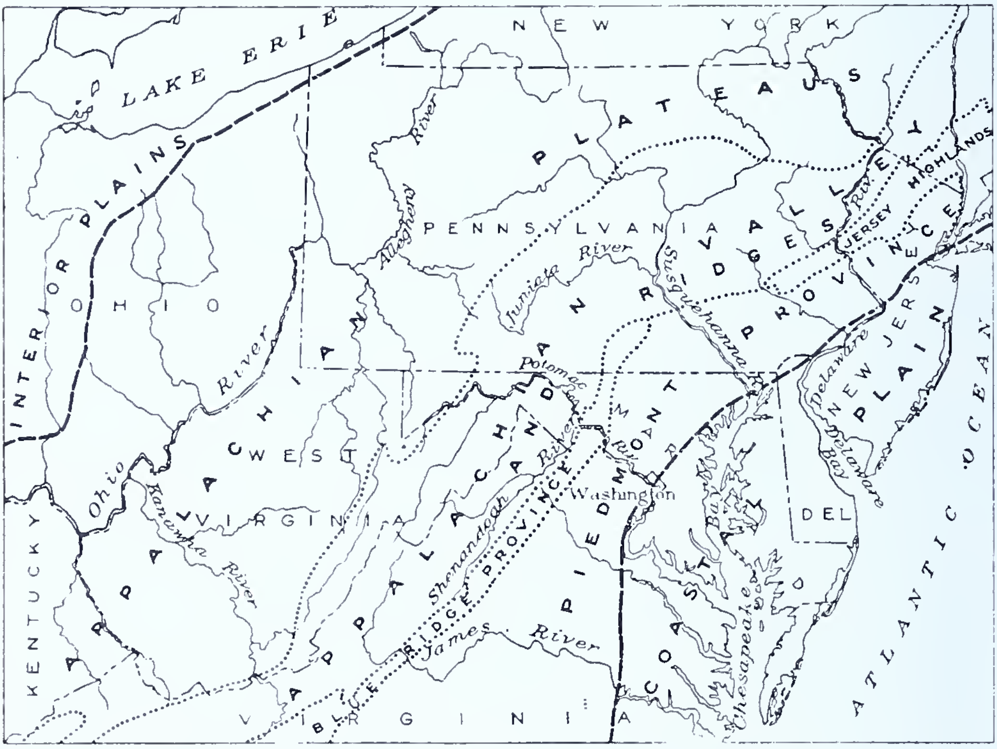

Figure 2. Physiographic sub-divisions of Pennsylvania.

Synopsis of geologic history. Historically the region has passed through four great epochs which determined its present condition.

1. From early Cambrian time to near the end of the Carboniferous (550-200 million years ago) what is now Pennsylvania was a shallow sea receiving sediments from a large land area at the southeast. The sea sank as it became filled with sediments and the land at the east rose, was weathered and eroded. At the end of Carboniferous time. 30,000 feet of sediments had accumulated east of Allegheny Mountains, but were thinner to the west. Limestones and shales indicate low land at the east; widespread sandstones indicate uplift and more rapid erosion at the east.

2. Near the end of Carboniferous time, mountain-making forces shoved these deposits westward, crushing and telescoping them at the east, folding and faulting those in the center and only slightly folding

the rocks west of the Allegheny Front. This left Pennsylvania temporarily a land of high mountains.

3. During and following the folding, erosion cut down the folds and ultimately wore them down to a plane, or peneplane just above sea level. But the final plane, from which when uplifted, the present topography was carved, dates from late Tertiary time, or not many million years ago. The original drainage is thought to have followed the bottoms of the low folds and to have encircled the ends of the anticlines and to have flowed to the southwest corner of the State. Later swift, because short, southeast-flowing streams penetrated the mountains, captured the drainage from this area and diverted it to the southeast. Such divergence is still going on actively in this immediate area and will be referred to later. At the time of the formation of the last or Schooley peneplane, the drainage to the southeast had established itself as far west as a line though Cumberland, Altoona and just east of Bells Landing in this area.

4. Probably in middle Miocene time or later the Schooley peneplane began to rise and to be eroded. Uplift continued probably until late Pliocene time. It is believed that the plane, if restored, would rise high above the present mountains of Pennsylvania though descending almost to sea level at Philadelphia where some interstream divides are still coated with gravel (Bryn Mawr). In the down cutting that followed uplift of the Schooley peneplane a variety of actions took place. In some instances, erosion cut the surface down until hard sandstones were encountered so that today a hill top or mountain top may represent a stripped bed of sandstone and the height of the mountain depends upon the structure and altitude of the sandstone. In other instances, a stream somewhere along the line encountered a hard massive sandstone that greatly delayed down cutting until the softer rocks in the drainage basin above had been reduced to a level plane on which the streams may have acquired meandering courses. It is possible though not yet proven, that the general uniformity of the hill tops in the Clearfield area, as well as the meanderings of the West Branch both below and above Clearfield, owe their origin to such delayed down cutting at a time when the drainage of all of this region was flowing through a gap in Bald Eagle mountains just south of Montoursville, a gap later abandoned for an easier course around the end of the arch that now has become Bald Eagle Mountain. That gap is today 1,250 feet above sea level. The erosion plane that must have formed behind it would naturally have some rise upstream, to which must be added any possible continuance of the uplift of the region accompanying the uplift of the Schooley peneplane.

Still other surfaces may be level topped because, owing to their uniform structure and other facts, erosion has lowered the surface uniformly so that at any time it reflects the level character of the peneplane from which it started.

The final stage of the down cutting has been the development of the present drainage lines by advance and capture of the westward-running streams by eastward-running streams which, because of their shorter distance to the sea, have steeper gradients and more cutting power.

Allegheny Mountains section

Relief. The Allegheny Mountains section, extending from Allegheny Mountain on the east to and including Chestnut Ridge on the west, forms a belt of high land 25 to 35 miles wide on the east side of the Appalachian Plateau province. The mountain ridges in this section reach 3,200 feet near the south line of Pennsylvania and still higher farther south. These elevations decline to 2,500 feet or less in southern Clearfield County, but rise to about 2,600 feet in the Endless Mountains in Sullivan County, Pa. The inter-mountain area is generally high, 1,800 to 1,900 feet on the uplands of southern Clearfield County, but becoming higher to the north and south. Into this upland the streams have cut valleys 400 to 600 feet deep.

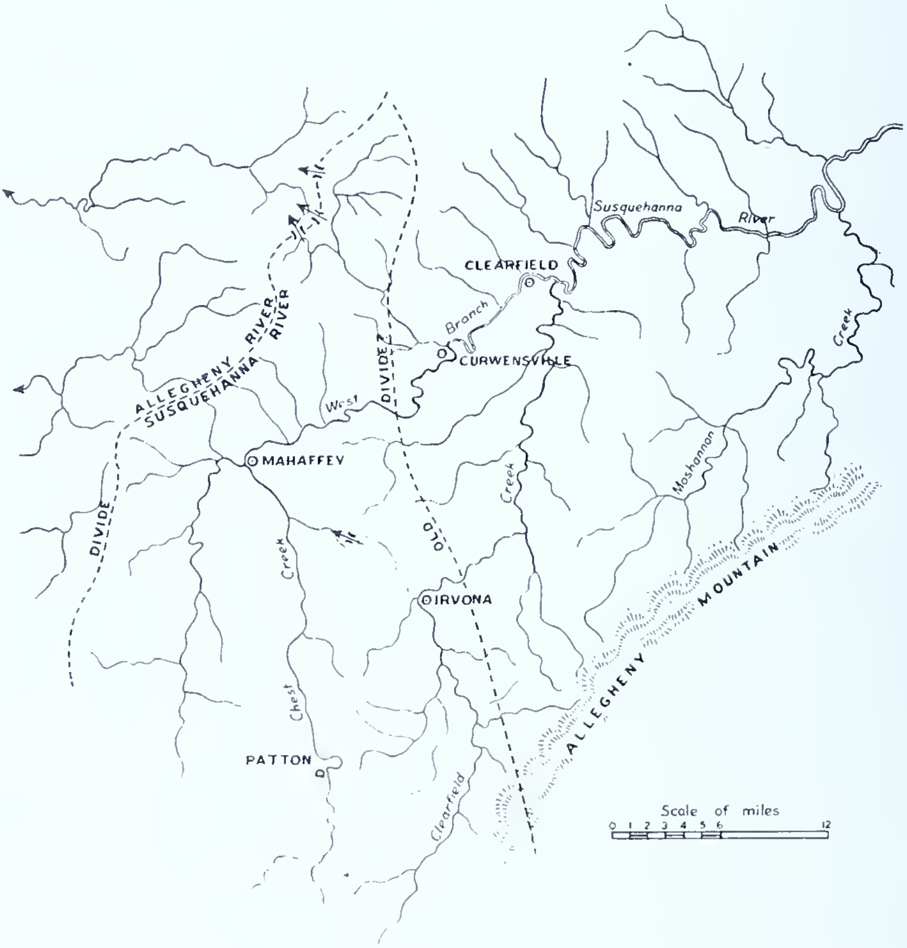

Figure 3. Drainage of part of the Allegheny Mountains section.

Drainage. Figure 3 shows that the drainage of the central and northern parts of this section in Pennsylvania is eastward to the Susquehanna. The southern part drains westward to the Ohio. Detailed study reveals that part of the eastward drainage formerly flowed northwestward and has been captured and turned to the east. Apparently, the West Branch above McGees Mills, Chest Creek, and the part of Clearfield Creek above Irvona, flowed northwestward toward Lake Erie. The headwaters of Anderson Creek have been diverted to the Susquehanna so recently that the gaps through which they ran west toward DuBois are plainly visible. It may be noted that in preglacial time all of the westward drainage flowed northwest to a master stream in what is now the Lake Erie basin. The glacial ice closed these northwest outlets and turned the drainage to the southwest around the ice front, resulting in the present Ohio below Beaver and the present Allegheny River.

Stratigraphy. The surface rocks in the Allegheny Mountains section consist of the Middle and Lower Pennsylvanian system or "Coal Measures". Locally, on the top and flanks of the anticlines or in the river gaps and on the steep escarpment on the east flank of Allegheny Mountain these have been removed and the underlying rocks have been exposed. The Coal Measures in western Pennsylvania consist of the basal Permian, the Monongahela, Conemaugh, Allegheny, and Pottsville groups in order. They have a thickness of 2,500 feet or more and consist of sandstones, shales, coals, clays, and limestones, with some iron ore. Beneath the Pennsylvanian, as revealed in the Allegheny Mountain escarpment and eastward, and therefore underlying this area, is the following section:[1]

Mauch Chunk shale. Mainly lumpy red shale or mudrock, with 80 feet of thick-bedded sandstone at bottom to west. A little thin sandstone and limestone to east. Mostly of Chester age. 180-1,000 feet.

Loyalhanna limestone. Siliceous cross-bedded limestone to west; gray and red, partly argillaceous limestone to east, St. Genevieve age. 60 feet.

Pocono formation. Thick-bedded, gray sandstone; Burgoon member at top; shale, red shale, and sandstone below. Conglomerate at bottom to east. Thickest to east, in Broad Top Mountain. Much red shale at west, on Allegheny Front. Waverly age. 1,000-1,170 feet.

"Catskill" formation. Lumpy red shale or mudrock and thick-bedded, micaceous, red sandstone; 80 percent red. Gray and greenish shale and gray sandstone with marine fossils, 20 percent; 1,600-2,500 feet thick on east, 500 feet or less at west.

"Chemung" formation. Mostly shale with thin sandstone layers. Some thicker sandstone and conglomerate members. Upper 1,000 feet largely purplish or chocolate-colored on Allegheny Front, and the same with red shale layers in the upper 500 feet on Raystown Branch of Juniata River on the east. Lower 2,000 feet gray and greenish. Chemung fossils common to abundant from bottom to top. 2,400-3,300 feet.

Brallier shale. Fine-grained, siliceous shale in thick, even layers revealing their fissility on weathering. Largely wavy or dimpled laminæ, some even and slaty. A few thin, fine-grained sandstone layers. Upper Portage. 1,350-1,800 feet.

Harrell shale. Dove-colored and black fissile (paper) shale. Black at bottom to west (Burket member). Black and dove-colored interbedded to east. Lower Portage. 250 feet.

Hamilton formation. Hackly shale at top, weathers green; impure limestone layers in top 10 to 20 feet. Dark shale with thin even sandstone layers in middle to west, three thick sandstone members to east. Lower one-third dark olive shale grading into Marcellus shale below. 800-1,200 feet.

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[1] Butts, Chas., Geologic section of Blair and Huntingdon counties, central Pennsylvania, Am. Jour. Sci., XLVI, 1918, pp. 523-537.

Marcellus shale. Black fissile shale. 150 feet.

Onondaga formation. Dark shale with limestone layers. 50 feet.

Ridgeley sandstone. Coarse thick-bedded sandstone. Upper Oriskany. 100 feet.

Shriver limestone. Thin-bedded siliceous limestone. Lower Oriskany. 200 feet.

Helderberg limestone. Thick-bedded gray limestones (Keyser, Coeymans, New Scotland). 150 feet.

Tonoloway limestone. Thin-bedded limestone. 450 feet.

Wills Creek shale. Dove-colored calcareous, fissile shale, a little limestone. Bloomsburg red member, red and green shale, impure limestone and red sandstone—bottom 50 to 150 feet. 600 feet.

McKenzie limestone. Limestone and shale. 275 feet.

Clinton formation. Mainly greenish shale weathering purplish. Some sandstone. Thin but workable iron ore beds. 800 feet.

Tuscarora quartzite. Thick-bedded white quartzite. Extensively used for silica brick. Called ganister. 400 feet.

Juniata formation. Red lumpy shale or mudrock, red and greenish-gray sandstone. Some finely cross-laminated. 850 feet.

Oswego sandstone. Medium thick-bedded gray sandstone. Some finely cross-laminated. Bald Eagle sandstone of Grabau. Oneida conglomerate of Pennsylvania Second Geological Survey. 800 feet.

Reedsville shale. Thick, dark, rusty weathering, sandstone at top. Maysville age. Persistent to Tennessee. Shale with thin limestone layers in upper half. Fissile (shoe peg) shale in lower half. Black shale at bottom with graptolites. Eden age. 1,000 feet.

Trenton limestone. Thin-bedded black limestone weathering gray. 320 feet.

Rodman limestone. Dark crystalline limestone weathering with a rough granular surface; very characteristic and persistent. Upper Black River. 30 feet.

Lowville limestone. Dark, thick-bedded, pure limestone, glassy to fine-grained. Extensively quarried for flux. Lower Black River. 180 feet.

Carlim limestone. Dark, fine-grained limestone, extensively quarried for flux. 180 feet.

Bellefonte dolomite. Thick-bedded dolomite yielding much dense chert. 1,000 feet.

Axemann limestone. Thin-bedded blue limestone with dolomite layers. 100 feet.

Nittany dolomite. Thick-bedded, cherty dolomite. 1,000 feet.

Larke dolomite. Thick-bedded, coarse, steely blue dolomite. 250 feet.

Mines dolomite. Cherty dolomite, oolitic, yields much oolitic and platy scoriaceous chert. 250 feet.

Gatesburg formation. Thick-bedded, steely blue, coarsely-crystalline dolomite with many interbedded quartzite layers up to 10 feet thick. 1,750 feet.

Warrior limestone. Thick- and thin-bedded blue limestone with thin siliceous shaly layers or partings. 1,250 feet.

Pleasant Hill limestone. Thick-bedded limestone at top. Argillaceous thin-bedded limestone at bottom weathering to shale.

Waynesboro formation. Sandstone, conglomerate, and red and greenish shale. 250 feet.

This section thins westward to central Ohio.

Structure. In contrast with the close folding and faulting to be found in the Appalachian Valley and eastward, in Allegheny Mountain and westward the folding is gentle. The rocks were never lifted very high and the coals and black shales still retain a considerable portion of their original volatile constituents. It has been suggested by Arthur Keith that Allegheny Mountain may lie just above the old shore line of the basin in which the Lower and Middle Cambrian sediments were deposited on the east and, if so, it may have served as a stumbling block or check on the folding movement. Whether that is true or not, there is a distinct change in the structure at the eastern edge of the Allegheny Mountain section.

Allegheny Mountain itself is sustained by the Pottsville and Pocono sandstones separated by a small thickness of Mauch Chunk red beds, all plunging westward on the west flank of Nittany anticline which centers in Nittany Valley. In central Pennsylvania opposite Clearfield County, the western flank of the anticline is simple, but to the north and south the folding is more complex. Opposite Cambria County, a minor anticline with a syncline to the east carries the actual edge of steep folding several miles east of Allegheny Mountain. Farther south, as at the Pennsylvania-Maryland State line, a wide but not high anticline exposes a broad belt of Upper Devonian rocks beyond which another syncline brings down all of the Coal Measures to form the Georges Creek-Potomac coal basin which broadens southward and contains some minor folding.

West of Allegheny Mountain lie two minor anticlinal folds, Laurel Hill and Chestnut Ridge anticlines, and some intermediate folds, of which one, the Negro Mountain anticline, because of its breadth, lifts the rocks to an altitude higher than the mountains on both sides. These major anticlines expose the pre-Pennsylvanian uppermost Devonian strata in their cores where cut by streams. In contrast with the fairly steep dips in Allegheny Mountain, Laurel Hill, and Chestnut Ridge, in other parts of the Allegheny Mountains section the strata lie nearly flat or are only gently folded. In southeastern Clearfield County several faults displace the strata up to 200 feet.

THE TOPOGRAPHIC MAP

The topographic map shows the geography of the area, that is, the position of the hills and valleys, the rivers and roads, the houses, towns, and railroads.

The map is founded on the ascertained position of some of the most prominent hilltops of the region, these positions having been established by triangulation connecting with astronomical stations at Washington, D. C., Cumberland, Md., Grafton, W. Va., and Pittsburgh, Pa., and the accuracy of the work has been checked by carefully measured base lines. The details of the map have been worked out by plane table triangulation, and surveyed lines along the roads, railroads, ridges and elsewhere. The methods by which such maps are made are described in U. S. Geological Survey Bulletin 788, Topographic Instructions, and a description of the triangulation stations and level lines is given in Appendices A and B.

Contour lines. The map is covered with brown contour lines. As the meaning of these lines may not be familiar to those not accustomed to using such maps, a word of explanation may help.

In general the lines are somewhat parallel, and every fifth line is heavier than the others. They are intended to show the position of lines of equal elevation above sea level; for example, if the ocean were to rise 1,500 feet higher than its present level it would fill up all of the lower valleys of the quadrangle and extend up the hill slopes and smaller valleys as far as the heavy brown line marked 1500. Were it to rise another hundred feet, it would extend up to the line marked 1600, and so on. Where the lines are close together the slope is steep, and where they are far apart the slope is gentle. In general it is assumed that the slope is uniform between any two of these lines. There is one line for each 20 feet of elevation. The fifth lines, representing the 100-foot contours, are emphasized by being widened.

This method of representing the surface configuration of the ground is not so pictorial as some other methods, but it has the great advantage of representing the surface with more or less mathematical accuracy. In other words, if a house, or a mine, or other object lies between contour lines 1800 and 1820 it is assumed that its elevation above sea level is between 1800 and 1820 feet, and in general it may be assumed that its elevation is nearer one or the other of those figures in proportion as it is nearer one or the other of the lines. In this way it is possible from the map to estimate the elevation of any point within perhaps 5 or 10 feet, and thus to make comparison between the elevations of any number of points. Actually, except along roads or other lines where levels were run, it is not safe to assume so close a figure. In general, however, the elevation determined on the map is supposed to be within 20 feet of accuracy.

Altitude of region. Though this area lies in what is sometimes known as the Allegheny Mountain region, it would hardly pass as a mountainous district. The land lies between 1,100 and 2,200 feet above sea level. The principal valleys lie between 1,100 and 1,350 feet above sea level. A large part of the upland of this part of the county ranges from 1,700 to 2,000 feet above tide. Altitudes in any part of the area can readily be determined from the brown contour lines as already explained.

Surface relief. In general the surface of this part of the county consists of gently rolling uplands, in places almost flat-topped, with narrow, steep-sided valleys. The larger valleys have some bottom land. Although much of the upland appears as open, rolling farm land (see Figs. 4 to 7), the valleys, from which most railway travelers see the country, give the impression of a rather wild, broken country, little inhabited.

Standing on the top of any of the ridges west of Chest Creek and looking east or northeast, it will be noted that the horizon is remarkably even and of uniform elevation. The same is largely true in looking from the summit of any high point in the area. A study of the topographic map shows that in the Curwensville quadrangle south of Susquehanna River 75 distinct areas rise above 1,800 feet and only 13 points rise above 1,900 feet; and that west of Chest Creek 14 distinct areas rise to 1,800 feet and none above 1,850.

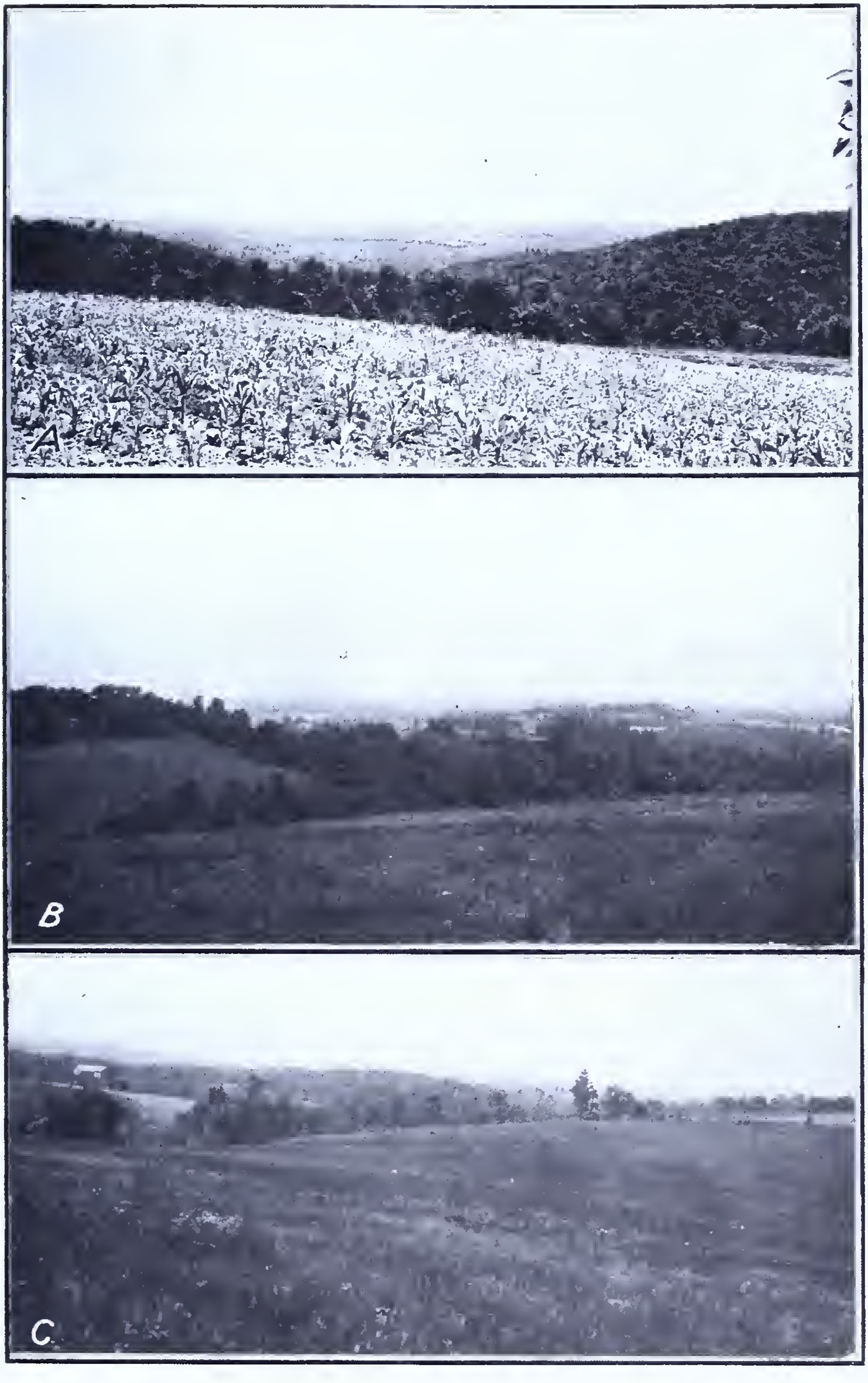

Figure 4. Views on upland to show sublevel character.

A. Looking east from one mile west of Faunce.
Photograph by S. W. Lohman.

B. View north from one mile south of Ansonville.

C. View east from one mile northeast of Berwindale.

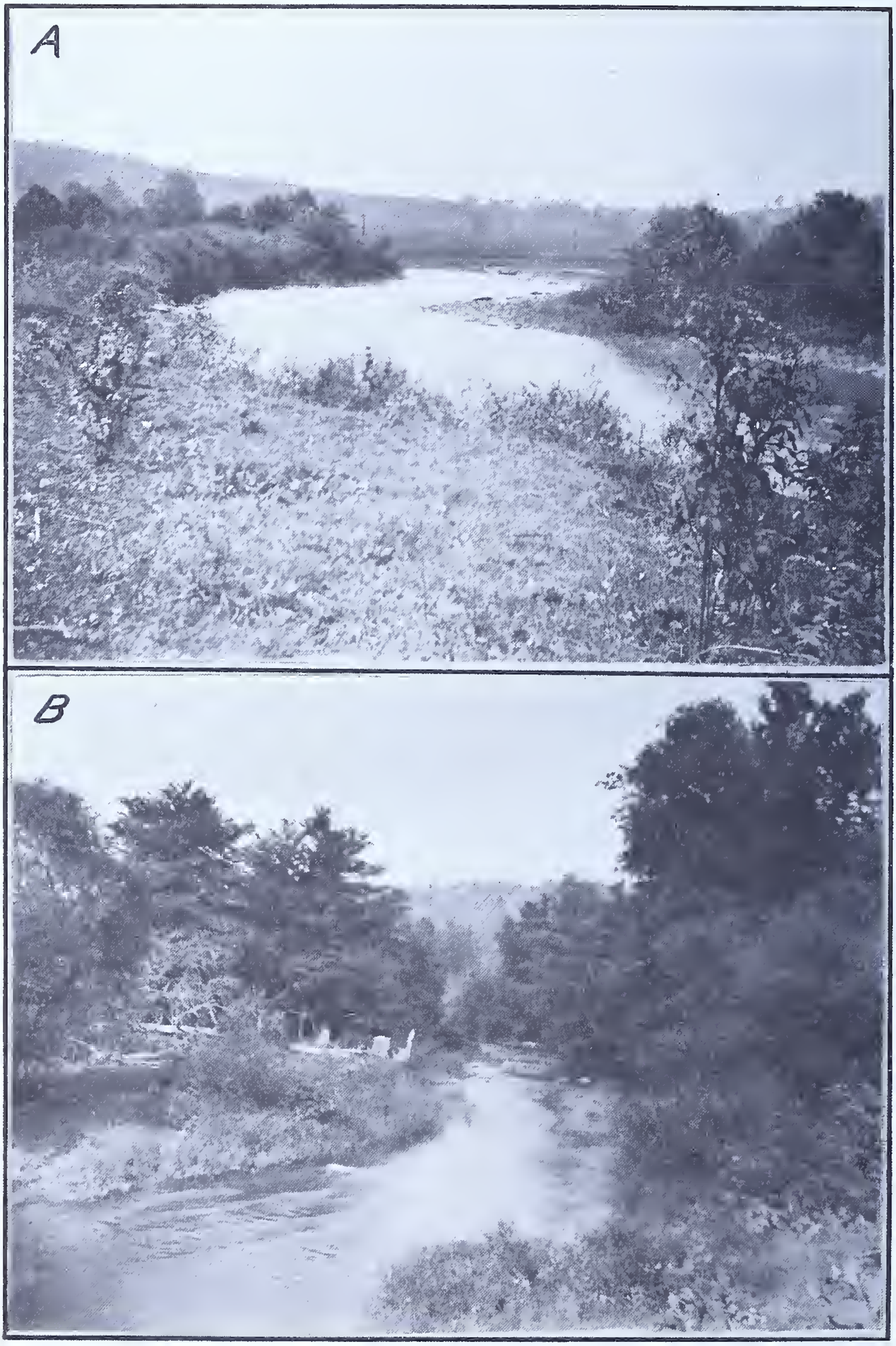

Figure 5. Views in "old" valleys.

A. Valley of Chest Creek near La Jose.

B. Wilson Run Valley, southeast of La Jose.

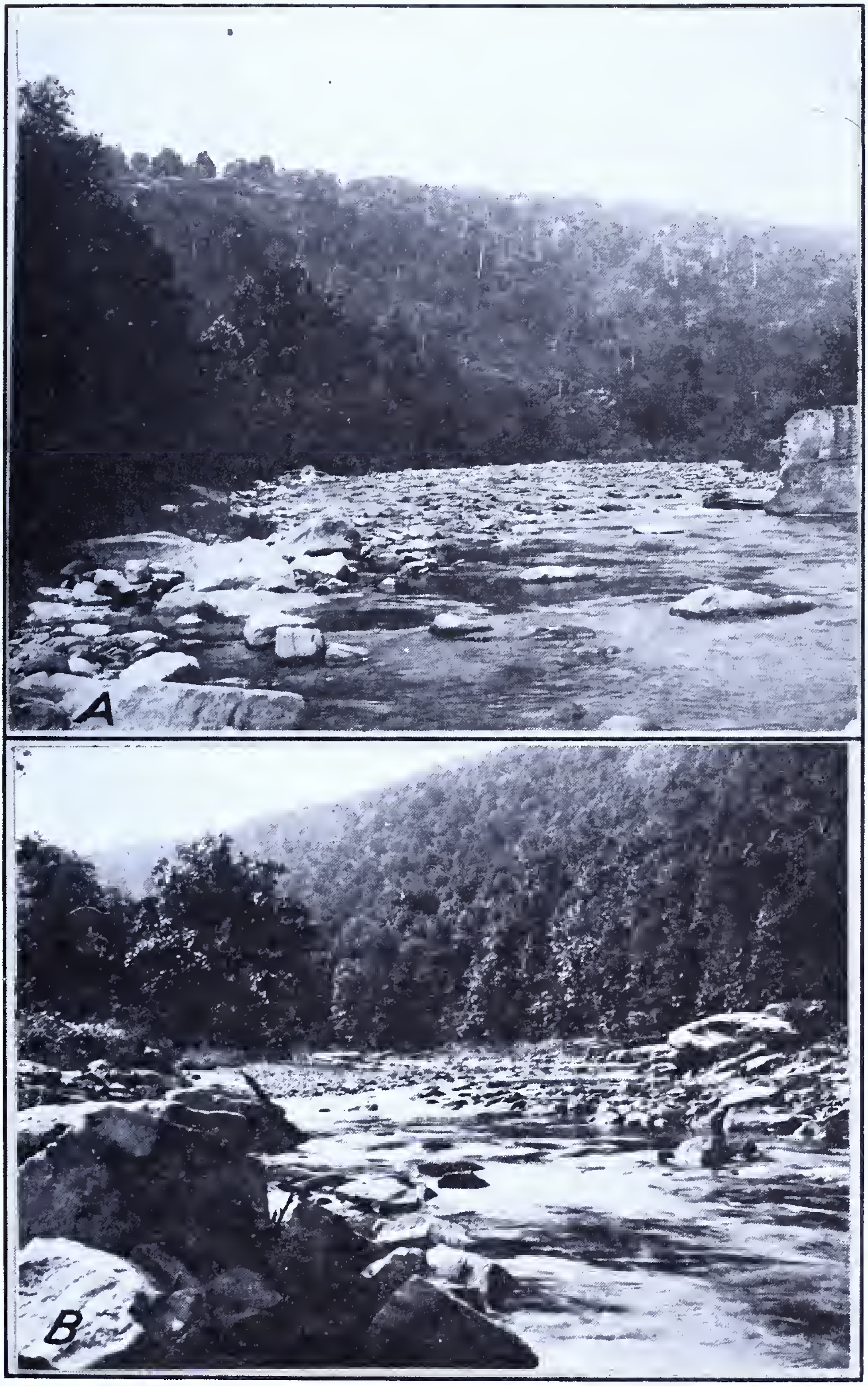

Figure 6. Views in "young" valleys; or valleys of streams enlarged and deepened by the capture of streams which formerly ran northwest.

A. Valley of Anderson Creek, one mile south of the quadrangle line.

B. Susquehanna River at Chest Falls, two miles northeast of Mahaffey.

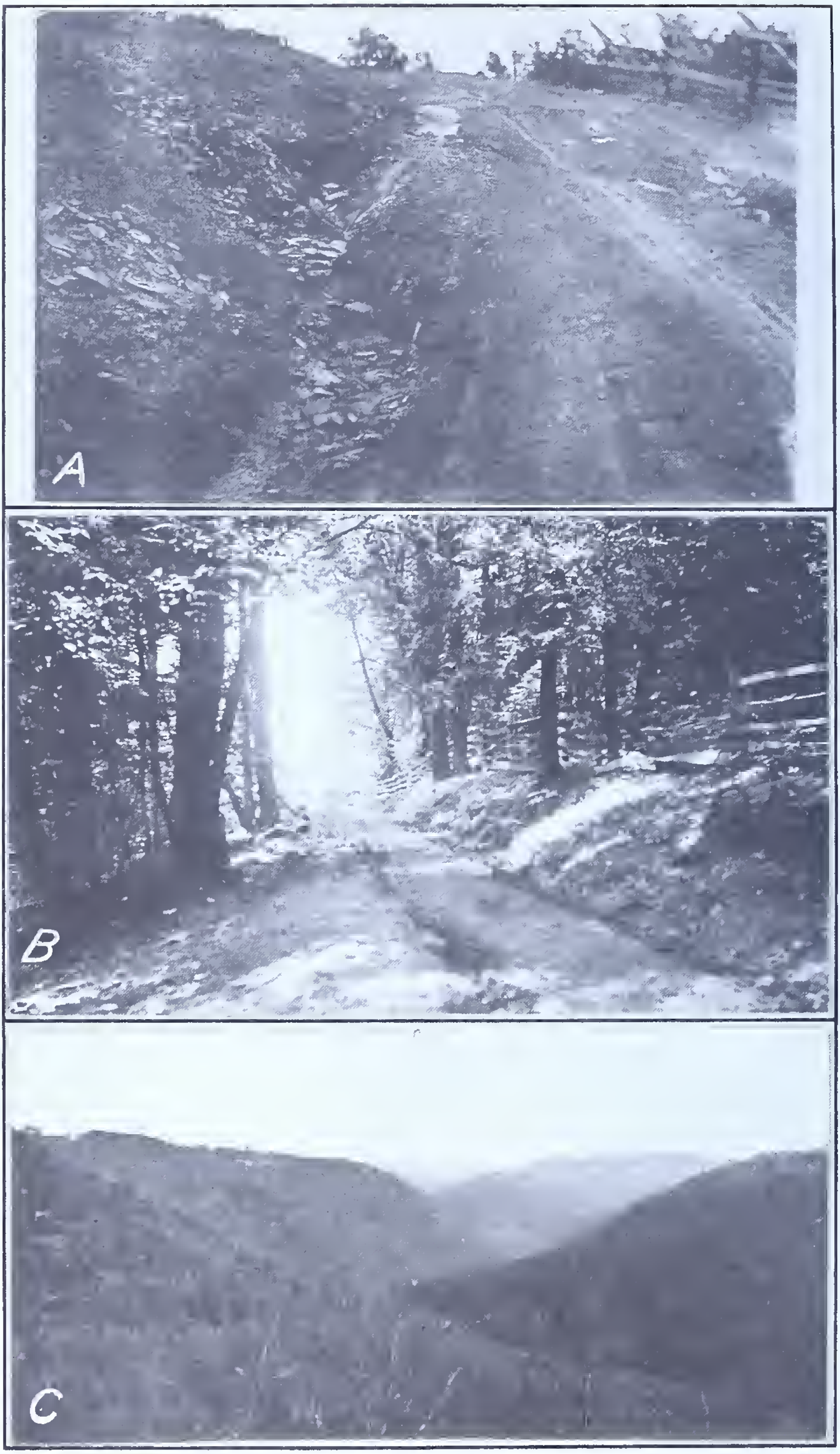

Figure 7. Views showing conditions as affecting geologic work.

A. Typical roadside gutter, the principal source of information.

B. About two-thirds of the area is forested as typically shown here.

C. The northwestern and northern edge of the quadrangle present these conditions. Anderson Creek Valley from Blooms Run quarries.

General character of surface. The Allegheny Front lies only a short distance to the southeast and the extension of Chestnut Ridge, which is a prominent mountain in the southwestern part of Pennsylvania, crosses the northwest corner of the Curwensville quadrangle. The larger part of the area, therefore, lies in the broad basin between the uplifted rocks forming the Allegheny Front and the pronounced arch crossing the northwest corner, which forms Chestnut Ridge. Between them in this quadrangle the rocks have rather gentle dips, and no high ridges break the general evenness of the surface. In general the land is composed of broad, fairly even, rounded, and occasionally flat divides, from which the surface descends rapidly to streams having little bottom land. The general type of topography, therefore, may be expressed as narrow V-shaped valleys separated by broad to narrow uplands. The valleys are from 200 to 500 feet below the adjacent uplands and have little cultivable land in contrast with the well-farmed uplands. The railroads of necessity follow the valleys. The whole effect of the uplands is that of a gently rolling, level country. This is often heightened by the fact that some of the tributaries of the main streams have very broad shallow valleys at their heads. Portions of Susquehanna River, Chest, and Clearfield creeks, as well as Little Clearfield Creek, have some bottom land. These bottom land areas, as a rule, coincide with the synclines or structural basins, as shown on the structure map. Where the streams cross the anticlines, they are usually extremely narrow and have little or no bottom land. In many instances this is due to the fact that the anticlines or arches bring up the hard Pottsville sandstone, which resists the widening of the valley. It is apparent that the flat-topped divides and narrow stream channels are the result of the physiographic history which this region has undergone in common with the rest of the Appalachian province.

The sub-level tops were formerly held to be related to one of the lower and later peneplanes, probably that called by M. R. Campbell the Harrisburg peneplane. Today it is held that, while in general they reflect the Schooley peneplane, which may have been, after uplift, 4,000 feet or more above sea level, local base levelling may have had a large part in determining the concordance of the hilltops.

It is not unlikely, though not yet proven, that many of the sub-level hilltops at 1,800-1,900 feet above sea level reflect a more recent local base levelling owing to the delayed downcutting of the river through Allegheny Mountain above Lock Haven, or more particularly through a former gap across Bald Eagle Mountain just south of Montoursville. This gap, now at 1,220 feet, quite certainly is responsible for an old level, now only reflected in the fairly uniform elevation of hilltops at 1,200-1,400 feet over the broad area in the Bald Eagle Valley between Bald Eagle Mountain on the south and Allegheny Mountain on the north from Muncy to Lock Haven and beyond.

Drainage. The drainage is readily noted on the map though it may be well to call attention to certain details. It was suggested above that the westward courses of the West Branch above McGees Mills, of Chest Creek, and of Clearfield Creek above Irvona, may reflect the time when those streams all ran northwestward to Mahoning Creek, and that the Susquehanna River, heading near Bells Landing, cut across the divide and captured them, turning their waters eastward. How this may have happened is well illustrated by conditions at Patton today.

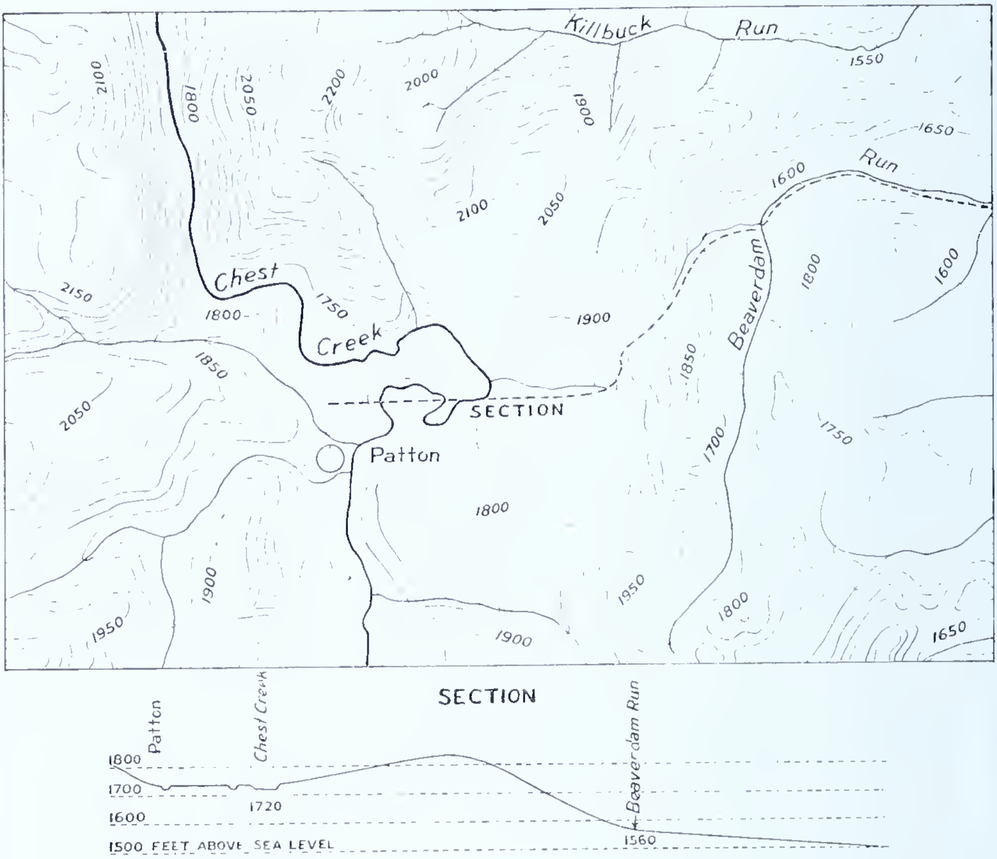

Figure 8. Topography at and near Patton, Cambria County, to show the approach of stream capture.

At Patton, Chest Creek is flowing at a level just under 1,720 feet, 1.1 mile to the east, Beaverdam Run has lowered its valley to 1,650 feet, and 1.3 miles northeast to 1,560 feet above sea. Obviously, with its steeper gradient, the drainage to Beaverdam Run will wear the east side of the divide faster than a tributary of Chest Creek will wear the west side. As a result the divide will be pushed nearer and nearer to Chest Creek until that creek is tapped and the part above Patton flows eastward to and down Beaverdam Run to Clearfield Creek. Just such a tapping is believed to have taken place at Irvona and at Mahaffey. The tapping of the upper part of Anderson Creek by the lower part is clearly indicated by the topography as shown on the Penfield topographic map. The gap at Mayes was clearly that part of the old Clearfield Creek valley before it was tapped at Irvona, or rather the present gap has descended from the original gap formed by Clearfield Creek. The deeply incised meanders of Clearfield Creek below Madera are thought to indicate that it was let down onto the Laurel Hill arch from a level surface some distance above the present surface.

Among other interesting features of the drainage is the narrowness of the river valley above and below Lumber City. The tributaries of Little Clearfield Creek in several places rise within ¼ to ½ mile of the river; and on the north, the head of Little Anderson Creek, south of Hepburnia, rises within ¾ mile of the river. These features suggest that at this point the present river may be running in a young channel cutting across an old divide. The appearance of youth is heightened by the fact that in this area the tributaries flowing away from the river have low gradients, while those flowing toward the river have high gradients. The grade of the head of Little Anderson Creek is about 25 feet to the mile as compared with nearly 600 feet to the mile for the river tributary heading against it. Some of the streams flowing away from the river seem to lie in hanging valleys. Were this part of the valley old, the steep tributaries should have eaten through the divide and captured the headwaters of Little Clearfield Creek and of Little Anderson (Cratcher) Creek.

Culture. As already described, the uplands of this area are sublevel, as a rule, and well tilled where the surface is not covered with sandstone blocks. Where the upland is underlain by massive sandstone, its weathering product so covers the surface as to make agriculture impossible. The streams form the avenues for the railroads and some of the principal roads. The presence of the railroads has led to the building of the later and larger towns in the valleys. At present, this area is well supplied with railroads. Lumbering and later coal mining induced their construction. Railroads cross in several directions and branch lines extend up many of the valleys to mining camps, giving ingress for freight and passengers. The New York Central Lines cross the county, following up the West Branch of the Susquehanna and up Chest Creek, this branch serving as a coal supply for that railroad and its trade. From Mahaffey the Central Lines extend up the West Branch of the Susquehanna.. The Bells Gap branch of the Pennsylvania Railroad enters this area at Coalport near the southeast corner of the Curwensville quadrangle, and crosses diagonally to the northwest. (In 1938, the section over the divide from Berwindale to the Elton mine had been taken up.) From Mahaffey the Pennsylvania Railroad has a line up the West Branch of Susquehanna River. The Tyrone Branch enters the county at Osceola Mills, runs to Clearfield and Grampian, with spurs to all of the mining centers in the area.

The principal boroughs of the region are Curwensville, Irvona, Rosebud, Coalport, Mahaffey, Grampian, and Westover. Among the smaller places are La Jose, New Washington, Curry Run, Bells Landing, Lumber City, Olanta, New Millport, Ansonville, McCartney, Kerrmoor, Berwindale, and mining settlements of transient character.

STRATIGRAPHY

Difficulty of mapping. This area, like some others in Pennsylvania, has few outcrops and no real key beds. Most of the coal field area carries some stratum that can be definitely identified wherever found, such as the Vanport limestone in the Lower Allegheny group, the Brush Creek or Ames limestone in the Conemaugh, and the Pittsburgh coal in the Monongahela, that give a definite starting point from which to measure to other beds, enabling the geologist to determine or identify those other beds with almost equal accuracy. No such bed or combination of beds was found in this area. Some beds can be traced with confidence for a few miles, but uncertainty may still exist as to just what beds are being followed.

Even greater difficulty exists because of the lack of outcrops. When the writer first came into this area in 1903, his most recent experience had been in the Southern Appalachian Coal Fields where the steep mountain ravines gave clearly exposed sections of the rocks for hundreds of feet. He soon learned that the ravines of this area are all lined with talus, some to depths of 60 feet, and as a rule yield little or no information regarding the underlying rocks. Most of the steeper hillsides are covered with debris from all the rocks above. It was sometimes possible to trace what was assumed to be the top of a sandstone by the upper limit of sandstone fragments in the soil. On cultivated land, the upper limit of stone fences likewise might suggest where the sandstone bed crops out. In the end the principal reliance had to be put on the partly exposed weathered outcrops in the drains beside the roads or in field ditches. As can be imagined, these were unsatisfactory and owing to down hill creep, often misleading. Over the Chestnut Ridge area an almost universal covering of second growth timber and lack of improved roads or cultivated areas rendered our conclusions in that area even more uncertain. These statements are made, not so much as an alibi, but as a warning that, because of these conditions in this area, not too much reliance should be put on the conclusions here presented.

The Chart. The Stratigraphic Chart (Plate II, in pocket) shows the succession and relative position of the rock strata in various parts of the quadrangle. A generalized section at the left gives the names of some of the more widespread rock strata, and the names used in designating groups of the rocks for general discussion and mapping. The sections are drawn on the scale of one inch vertically on the chart equals 125 feet in the field.

The meaning of the symbols used to show the various kinds of rocks is shown in the explanation (Fig. 14). The wedge-shaped drawing of the coal beds is to show the range in thickness of the coal beds in the area named. Likewise where sandstone is shown on one side of a section and conglomerate or sandy shale on the other, it means that the sandstone contains quartz pebbles in part of the area or grades into sandy shale.

None of the sections show the rocks observed in a single climb, because exposure of the rocks is incomplete at any one place. The sections, therefore, have been compiled from partial sections obtained in several places. Some of the sections have been further supplemented by the records of drillings. The sections are arranged from left to right as though crossing the quadrangle from west to east.

As the chart gives only a glimpse of the succession and distribution of the rocks, they will be described in the following paragraphs.

General character of rocks. The rocks exposed in this quadrangle, or that have been cut by the drill, are all of sedimentary origin; that is, they were laid down as sediments by water, just as sand, mud and lime deposits are being laid down along our coasts today. An examination of the chart shows a variable succession of sandstones, shales, coals, clays and limestones. The coals, clays and limestones occur in beds usually less than five feet thick. The sandstones and shales are of variable thickness, some reaching 50 to 75 feet. Comparing one section with another, it is evident that the lateral extent of the beds is very inconsistent. Probably some of the coal beds and underlying clays are the most persistent of any of the single beds. As a matter of fact, the clays underlying the coal beds are probably a little more persistent than the coals. Of the coal beds the one on which the sections have been aligned is probably a little more regular in this region than the other coals. It is called the Upper Freeport or E coal. About 200 feet below it is another bed, the Lower Kittanning or B coal, that is also quite persistent. Limestone, although seldom seen, and absent in many places, occurs in only a few horizons, and has a definite relation to the other beds. The sandstones and shales fill in the section, grading into each other both vertically and horizontally.

Variable character of the rocks. The variable character of the rocks is best shown by comparing the rocks in a series of sections, near each other. Figure 9 gives sections measured by the writer in the neighborhood of Curwensville and to the east. The sections show rocks above and below the Lower Kittanning coal and the variations in the coal bed itself.

The variations shown in these figures are typical of the Coal Measure rocks in general. It will be noted that one of the coal beds runs through the series with some degree of regularity. The minor coal beds, usually very thin, occur at variable horizons, apparently consisting of local pockets—unless the variable positions of the minor coals are due to changes in the thickness of the rocks above and below. Probably both factors apply.

Where similar studies have been made of thousands of sections or drillings instead of a score or two, it has been found that, although some of the variations are characteristic of the Coal Measure rocks, it has been possible to pick out certain elements of regularity. These form the basis for the grouping of the rocks that facilitates their study, description and mapping. Thus it has been found that:

1. The more important coals lie in beds often of considerable extent, in some cases thousands of square miles; within these large areas the coal bed is thin or wanting in areas of greater or less extent owing either to original non-deposition or to subsequent removal by erosion.
2. The minor coal beds as a rule are thinner and less extensive.
3. The clays under the coal beds are as persistent as the coal beds and possibly a little more so.

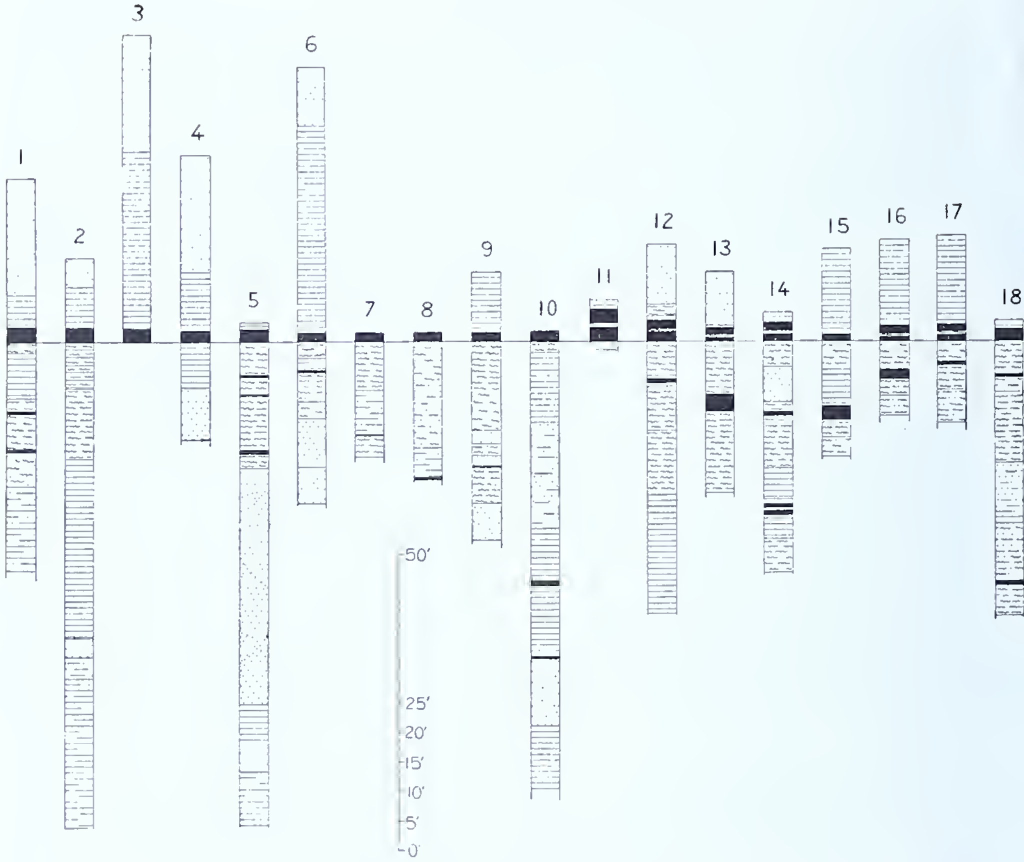

Figure 9. **Series of measured sections adjacent to the Lower Kittanning or B coal exposed in the railroad and road cuts around Curwensville and eastward, to show the variation in character of the rocks.**

1. Cut on New York Central Railroad, halfway between two county bridges south of Curwensville.
2. Cliff near new county bridge, 2 miles south of Curwensville.
3. Bluff ¼ mile west of New York Central Railroad depot at Curwensville.
4. Cut under road just south of New York Central Railroad depot.
5. Cut just east of Buffalo, Rochester & Pittsburgh Railroad depot at Curwensville.
6. Cuts, Pennsylvania and Buffalo, Rochester & Pittsburgh Railroads at east edge of quadrangle, near Susquehanna bridge.

7-8. Cuts, Pennsylvania Railroad, just east of Carbon mine.

9. Cut, Pennsylvania Railroad, a little east of Nos. 7-8.
10. Cut, Pennsylvania Railroad, west of Riverview Station.

11-13. Sections in stripping between Riverview and road south from West Clearfield.

14. Section of bank, Buffalo, Rochester & Pittsburgh Railroad, opposite Riverview.
15. Cut, Buffalo, Rochester & Pittsburgh Railroad, opposite Clearfield.
16. Cut, Buffalo, Rochester & Pittsburgh Railroad, 100 feet east of No. 15.
17. Cut, Buffalo, Rochester & Pittsburgh Railroad, 120 feet east of No. 16.
18. Cut, Buffalo, Rochester & Pittsburgh Railroad, just north of Pennsylvania depot, Clearfield.

4. The limestone beds, although of very irregular horizontal distribution, occur at only a few positions in the vertical column of rocks and, at those horizons, are widely though irregularly present.

5. The shales and sandstones, although usually of extremely variable extent both horizontally and vertically, can sometimes be traced long distances by cliffs, lesser outcrops, or debris.

Division into groups. It has not been found practicable to show on the relatively small scale map here used, the individual beds, on account of the thinness of the more persistent rock layers and the variableness of the thicker rock layers. The more persistent coals, clays and limestones have been named, and general names have, in some cases, been applied to any sandstones that occur within the space between two named beds of coal or limestone. The bituminous Coal Measures of Pennsylvania were early divided into several groups, based on lines drawn at the top and bottom of certain coal or limestone beds. The rocks that extend into this area have been divided into several groups, of which the most important here is the group extending from the top of the Upper Freeport coal to the base of the clay below the Brookville coal. This group, which contains practically all the workable coal beds in this area, is called the Allegheny group from its extensive outcroppings along Allegheny River. Above the Upper Freeport coal is the Conemaugh group, only part of which remains in this area, the rest having been removed by erosion. Below the Allegheny group is the Beaver River group of the Pottsville series ("Series" being used where several groups are considered together). These groups and the Pottsville series and others occurring in southwestern Pennsylvania are together called the Pennsylvanian system from their prominence in this State.

Underlying the Pennsylvanian rocks of this area are yet other rocks only slightly exposed in this quadrangle. The highest of these consists of sandstones and shales, the latter often red or green. The first 700 to 1,200 feet of these have been grouped in two series—the Mauch Chunk above and Pocono below. The two represent the lower part of the rocks of Carboniferous age to which the name Mississippian system has been given from their extent and value in the Mississippi Valley. Still below those are rocks of Devonian age which are of interest here mainly as a possible source of gas in this area.

The major subdivisions of the group are called members. The first column of the stratigraphic chart shows the principal members, the groups and their collection into systems.

As our information is most definite about the Conemaugh, the uppermost group, and decreases in descending to the older ones, the rocks will be described from the top downward in this district, beginning with the Conemaugh.

PENNSYLVANIAN SYSTEM

Pittsburgh Series

CONEMAUGH GROUP

Character and thickness. The rocks overlying the Allegheny group contain no widely workable coal beds and for that reason they have long been known as the "Lower Barren Measures" in contradistinction from an upper series of like small coal content. They extend from the roof of the Upper Freeport coal bed to the floor of the Pittsburgh coal underclay, and include a heterogeneous series of shales, sandstones, limestones and clays. As a rule, they are found in this area only in the hilltops in the synclines. The rocks composing this group are so variable in composition and geographic development that it is extremely difficult to obtain a section that may be regarded as at all characteristic of the area. If an observer confines his attention to any one section, he may be inclined to doubt this statement and to think that there are very distinctive beds in the Conemaugh group, but if an attempt is made to trace these distinctive members, it will be found that they have only local development and it is almost impossible to follow any one member continuously across a quadrangle. The total thickness of this group in western Pennsylvania is about 600 feet, increasing to more than 900 feet toward the Allegheny Front. The upper part of the group has been removed in this quadrangle so that not over 300 feet remain at any point. In general, not more than 100 to 150 feet of the group remain, and over large areas the group has been entirely removed. The Conemaugh of this county consists largely of sandy shale with some sandstone which, in places, becomes very coarse-grained and conglomeratic. As a rule, the sandstones do not make cliffs, but in certain areas are so massive that in weathering the ground becomes strewn with large boulders, suggesting in many places that quarrying would develop a stone of some value for rough structural work, such as bridge abutments. Some idea of the variableness of the strata in this region has been given in Figure 9. The Conemaugh group of this area contains the horizons of at least three coal beds, though at most of these horizons the coal is less than one foot thick. At three horizons occur sandstones of more or less persistence. The principal named beds in their order from the top downward are as follows:

Named members of Conemaugh group in Curwensville Quadrangle

Saltsburg member	Shale, red,	"Pittsburgh Reds"
	Sandstone,	Saltsburg
	Coal,	Bakerstown
Buffalo member	Shale,	"Lower Red"
	Limestone,	Cambridge or Pine Creek
	Sandstone,	Buffalo
	Limestone,	Brush Creek
	Coal,	Brush Creek or Gallitzin
Mahoning member	Sandstone,	Mahoning, upper
	Coal,	Mahoning
	Clay,	Thornton
	Shale,	Mahoning, lower
	Sandstone,	Uffington

The Mahoning member consists of an upper and lower sandstone, locally grading into shale, separated by the Mahoning coal, clay and limestone. The sandstones are known as the Upper and Lower Mahoning sandstone.

Typically in western Pennsylvania, the basal member of the Conemaugh, the Lower Mahoning sandstone, is a massive cliff-making sandstone, lying unconformably on a thin body of shale. In much of the Curwensville quadrangle the lowest 40 to 70 feet of the group is shale, ranging from a nearly pure clay shale to a very sandy shale or occasionally into sandstone. Thin layers of flinty shale occur in the lower half of this shale interval. They are fine-grained and hard and break into sharp-edged fragments like flint. These pieces, in a dirt road, make a distinct crunching noise when passed over by an iron-tired wagon. In places they grade into true flint clay which is usually too ferruginous for commercial use. An occurrence of flint clay in these beds in the Johnstown region has been called the Wehrum flint clay. A layer of very ferruginous limestone that grades into a calcareous iron ore occurs at the top of this shaly series in some places. Above this is usually a clay and over the clay a little black shale or thin bed of coal, the Mahoning coal. This coal is 40 to 70 feet above the base of the group. A trace of red shale occurs at this horizon in places farther west. As shown by the stratigraphic chart, in parts of the area the Lower Mahoning sandstone is well developed as a massive, coarse-grained sandstone.

The Mahoning upper sandstone, where present, overlies the horizon of the Mahoning coal. Locally this sandstone is massive and persistent, and a good quarry stone. It is prominent in the Curwensville quadrangle, only in the northwestern corner and on the ridge south of McPherron, and a few other places. As a rule, only the basal 30 to 40 feet of the sandstone is massive, though the whole thickness of the sandstone may be as great as 50 or 60 feet.

The Brush Creek or Gallitzin coal occurs just above the Upper Mahoning sandstone. It does not appear to be workable anywhere in this area though in places the coal bloom suggested a thickness close to two feet, indicating the possibility that it may be mined in the distant future.

About 60 to 80 feet of shale overlies the Brush Creek coal in many places in this region, though locally the Buffalo sandstone is massive and caps the ridge tops. The shale may be suitable for making paving brick and tile. It has been used a small extent in making paving brick at Punxsutawney. A distinct layer of red shale, found in many places to the west at the top of these shales or separated from them by a thin but massive sandstone, was not seen in this area. A fairly persistent coal horizon is indicated by coal blooms about 200 to 240 feet above the base of the Conemaugh group. This coal is correlated with the Bakerstown coal of the western part of the State. Attempts have been made to mine the coal at several points, though apparently with little success, as all openings on this bed had fallen shut when the area was examined. The sandstone under this coal, which may occupy the position of the Buffalo sandstone farther west, is massive in many parts of the area and locally conglomeratic.

Above the Bakerstown coal occur shales 20 to 70 feet thick containing a sandstone that is massive in the hilltops of Ferguson Township. This probably corresponds with the Saltsburg sandstone of southwestern Pennsylvania.

The difficulty in correlating the various members of the group arises largely from the lack of outcrops of the various beds. This area, as already described, is one of very few outcropping rocks and those are mostly of the lower groups along Susquehanna River and in railroad cuts. Only a few measurements were obtained of the Conemaugh coal beds. Their positions are indicated in a few places by coal blooms beside the roads but, in a large part of the area, the downhill creep of the rocks has covered any outcrops of the coals, limestones or clays, so that coal blooms or outcrops are found at such seattered localities, as shown upon the map, that it is difficult to correlate them from one point to another.

The debris from the more massive sandstones in the Conemaugh group has been the main dependence for working out the structure and position of the beds in large parts of the quadrangle. The Buffalo sandstone, for example, is massive in the central part. Its top has been estimated to be approximately 190 feet above the base of the group and the structure of the Upper Freeport coal has been determined by subtracting 190 feet from the elevation of the top of the sandstone as determined from sandstone fragments found on the hill slopes.

ALLEGHENY GROUP

CHARACTER AND THICKNESS

This group consists of sandstones, shales, fire clays, coals and limestones. The sandstones and shales predominate, with probably a little more shale, usually sandy, than sandstone in most of the sections. This is the coal-bearing formation of this area. The sandstones occur indiscriminately throughout the mass but are conspicuous at three horizons, to which the names Butler, Freeport and Clarion sandstones have been given. It has usually been assumed that the bounds of this group could be determined readily by its occurring between two massive sandstones, the Mahoning above and the Homewood below. It was mapped on that assumption in this region by the Second Pennsylvania Survey and during the first study of this area. However, it became evident that, although the rule would hold good in places, it would not hold good over most of the area. It was finally worked out that a massive sandstone, supposed to lie just above the Upper Freeport coal, belongs in the upper part of the Mahoning member and the showing of coal at its base is not the Freeport but the Mahoning coal, 70 feet above the Freeport upper coal. At the same time it was found that some of the massive sandstone supposed to delimit the base of the group is the Clarion sandstone within the group itself. The Homewood sandstone is not conspicuous in parts of this area, though it is massive and does delimit the base of the Allegheny in the north-central part of the area.

The group has seven coal beds in the Allegheny Valley, which is regarded as the type locality (Figure 10). These coal beds are of workable thickness at some points, at others thin and unimportant. As these coal beds form planes all through the group, a knowledge of their number, position and relations serves to give a better idea of the varying structure of the group than could be gotten otherwise. They are like the floors of a modern office building. Therefore they are treated here at some length.

The number of coal beds in this group increases eastward, there being 5 in the southwestern part of the State, 7 in the intermediate territory along Allegheny River, and 10 or more in this area. Seven horizons appear to carry coal widely and have been named from some locality where the coals are prominent.

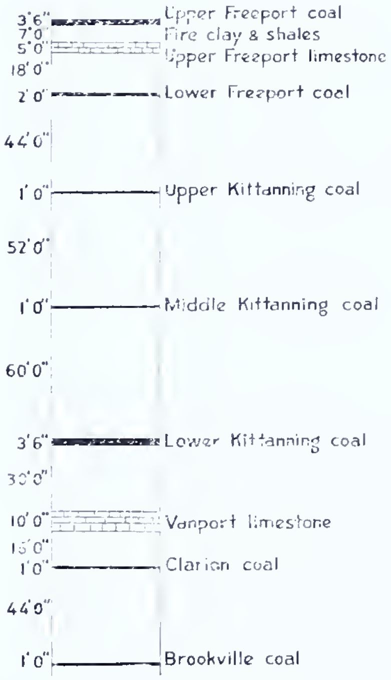

Figure 10. Typical section of the Allegheny group along the Allegheny River, indicating the position of the widely workable coal beds.

The coals of the Allegheny group received many local names in the work of the First Geological Survey of Pennsylvania. One of the important features of the work of the Second Survey was to show that the coal beds could be traced from one mining district to another and that the same name might be applied over practically all of the bituminous coal fields of the State. The work of the U. S. Geological Survey in the early years of the present century showed that, although some of the beds appear to occur persistently at certain horizons, the intermediate beds are not as persistent as has been supposed. Thus, in the Houtzdale Basin, just east of the Curwensville quadrangle, the Moshannon coal, generally correlated as the Lower Freeport coal, splits to the westward, the two benches getting as much as 55 feet apart. The lower bench has been mined extensively over a broad area to the westward of the splitting. In the Curwensville quadrangle, it is not always clear whether what is here called the Lower Freeport coal is one of the benches of the Moshannon coal or is the equivalent of the two benches brought together again. It would appear that in this region at least, there may be two beds about in the horizon of the Lower Freeport coal, and a section at any point may find these beds well separated or united into a single bed.

Several drill holes in this area show a dozen or more coal horizons in the interval considered to correspond with the Allegheny group.

As there are only seven coals in the typical section along Allegheny River, it is evident that these coals have either split up in this section or new coals have been introduced. These extra coals are in most places less than one foot thick. On the other hand, there is nothing in the section to indicate that some of these thinner coals do not occur at the horizon of one of the named coals of the Allegheny River section. A splitting somewhat similar to that known to occur in the Moshannon coal along Muddy Run also occurs in the Lower Kittanning or B coal in the Irvona region, though the evidence is not as good as in the former instance. The evidence suggests that the Lower Kittanning coal includes an upper bench of coal that is remarkably persistent and a horizon of irregular lenses occurring in some places so close under the upper bench as to be minable with it and at other places occurring from 2 to 15 feet below.

Another feature of this irregularity is the apparent variation in the intervals between the several coals within comparatively limited areas. Thus, the distance between the Upper and Lower Freeport coals is only 10 or 15 feet in some places, but a few miles distant this interval may be 55 or 60 feet. It is not clear in many of these instances whether this great variation is actual, possibly through the entrance of thick sandstone lenses, or owing to mistaken identity of the coal beds.

It is evident from these facts that too much stress should not be placed upon the exactness of correlations between the coal beds of this region and of the type region along Allegheny River. On the other hand, it has been clearly demonstrated that many elements of the section, especially the limestones, can be traced over large areas with considerable certainty. The truth probably lies between the two ideas: the first, that no correlations can be made between distant fields; and the second, that the principal Allegheny coals of all the fields in western Pennsylvania can be definitely correlated with one or another of these seven coal horizons. At the same time, it is not intended to imply that coal beds at two points to which the same name is given are at exactly the same horizon and actually connect through from one point to the other. For this reason, the common practice in this field of using letters to designate the coal beds, has been followed, implying thereby relative sequence and, to a certain extent, approximate or actual correlation. Thus coal E has been assumed to be the equivalent of the Upper Freeport coal on the Allegheny River.

Certain characteristics of the rocks associated with some of the beds suggest that the correlation of the principal beds with the corresponding ones along Allegheny River is quite close. In western Pennsylvania, the Upper and Lower Freeport and Upper Kittanning coals generally are underlain by limestone. Beneath the Upper Freeport limestone occurs locally a flint clay known as the Bolivar clay. The Lower Kittanning or B coal occurs very widely, approximately 200 to 225 feet below the Upper Freeport coal. The B coal is typically underlain by an unusual thickness of clay with which is often associated some flint clay, and under the clay is the Vanport limestone, which differs from the other limestones of this series of rocks, and has been traced over large areas in western Pennsylvania. Therefore, the finding in this region of two coal beds persistently about 200 feet apart—the upper one being the highest workable bed in the region and underlain in many places by a limestone and flint clay, and the other bed, 200 feet lower, commonly underlain by a clay of more than the average thickness—has suggested that the correlation of these two beds with the Upper Freeport and Lower Kittanning coals along the Allegheny River is correct. The Upper Kittanning coal appears to be associated in many places with cannel coal; so the finding of cannel coal in this area in association with a bed that appears to have the relative position of the Upper Kittanning, gives an additional check with the coal along Allegheny River.

The coals of this quadrangle have been named from the bottom upward; A corresponding in a general way with the position of the Brookville coal, A′ with the Clarion coal, B with the Lower Kittanning coal, C and C′ with the Middle and Upper Kittanning coals, and D and E with the Lower and Upper Freeport coals. There appears to be an indefinite number of thin coals. As many as 10 coal-bearing horizons show in a single drilling below the horizon of the D coal. Where all of the lower coals are thin, correlations are made largely on assumed intervals. In general, the interval from the E to the D coal averages about 40 feet; from the D to the C′ coal about 60 feet, making the interval from E to C′ coal about 100 feet or about one-half of the interval from the E to the B coal. The position of the C coal is somewhat uncertain, owing to the thin coals that occur in this region near its position and the uncertainty as to which of them should be called the C coal. The coal nearest halfway between the C′ and the B has generally been called the C coal, unless some other coal in that interval is much thicker. From the B coal to the A is usually from 60 to 100 feet, giving a total thickness for the formation of from 250 to 300 feet. The stratigraphic chart shows columnar sections indicating the positions of the principal named members from various parts of the area. The positions of the coals can be summarized here in a table:

Table of distances in feet between coal beds of Allegheny group in the Curwensville quadrangle.

	SE part	NE part	Western
Upper Freeport or E coal	—	—	—
	40	16 to 55 av. 45	50
Lower Freeport or D coal	—	—	—
	45	40	50
Upper Kittanning or C′ coal	—	—	—
	70	—	45
Middle Kittanning or C coal	—	—	—
	55	—	45
Lower Kittanning or B coal	—	—	—
Total E to B coal	210	210	190
	80	70	70
Brookville or A coal	—	—	—
Total thickness	290	280	260

The detailed stratigraphy of the Allegheny group varies so much from place to place that it is difficult to give a generalized section that will agree with what would be found at any one point. The generalized section on the stratigraphic chart is as good as can be compiled from the data on hand. At no point in the area is there a completely exposed section showing the various coal beds and their accompanying rocks. The lower part of the group is well exposed in the railroad cuts near Mahaffey and McGees. By combining the section exposed there with records from drill holes which cut the upper part of the group, a good general view of its make-up may be obtained. The following section gives more details of the strata than can be shown in the drawing.

Allegheny group

Generalized section of Allegheny group near Mahaffey and McGees

	Ft.	In.
Coal, Upper Freeport or E	2	7
Clay	6	
Limestone, Upper Freeport	5	
Clay	3	10
Sandstone and black shale	30	4
Coal, Lower Freeport or D	2	6
Fire clay	4	4
Shale, sandy	22	3
Shale, dark	22	4
Coal, position of, Upper Kittanning or C′, lacking in section.		
Fire clay	2	
Shale, light	2	
Limestone	3	1
Shale, light	17	6
Shale, dark	7	10
Shale, dark, sandy	15	
Coal, Middle Kittanning or C		10
Bony coal and shale	3	
Clay, drab and brown, grading into sandstone at bottom	4	6
Sandstone, light brown, thin-bedded to irregularly-bedded.	33	6
Coal, Lower Kittanning or B	1	10
Clay, light drab	3	
Clay, flint (Clarion)		6
Clay, light drab	4	6
Sandstone and shale	12	
Clay, light drab	5	
Iron ore, poor	1	
Clay shale	5	
Sandstone, shaly, carbonaceous	6	
Sandstone, massive to conglomerate (Clarion), stringers of coal in base	30	
Shale, with iron concretions, 4 inches to		6
Coal, Brookville or A, 16 inches to	4	
Clay, drab, sandy below, 4 feet to	8	

This section lacks the C′ coal and in that sense is not characteristic of the area as a whole, for that coal is usually present and in places is quite thick, owing to the presence of cannel coal. Nor does it show the coal between the A and B which is present in many areas. A series of sections of the rocks immediately above and below the B coal in the northeast corner of the Curwensville quadrangle has already been given in Figure 9.

The following section was obtained from the bluffs of Susquehanna River south of Curwensville:

Section south of Curwensville

	Ft.	In.
Shale, clayey to "sand-shale"	40	
Coal, bloom, "Mahoning"	—	
Shale, olive, and shaly sandstone	26	
Sandstone, shaly	10	
Shale, sandy, "sand-shale"	18	
Coal, Upper Freeport, E, 8 inches to	2	4
Clay, drab	4	
Sandstone, light brown	14	
Sandstone, shaly to "sand-shale"	20	
Shale, dark, fissile	12	
Coal, Lower Freeport, D coal, 2 ft. 2 in. to	2	4
Clay, 1 in. to		3
Coal, 7 in. to	1	
Clay, dark	3	
Iron ore, 0 to		3
Limestone, dark "blue," 0 to		10
Shale, drab	10	
Coal		9
Shale, dark, clayey	30	
Sandstone, shaly	10	
Shale, light, drab, sandy	20	
Hidden, 45 ft. to 65 ft.	50	
Sandstone	25	
Shale, light brown, 10 ft. to 30 ft.	20	
Coal, Lower Kittanning, B, 14 in. to	2	4
Clay, 6 ft. to	18	
Sandstone, massive-bedded to cross-bedded	25	

The following section was measured along the railroad switch southwest of McCartney:

Section along railroad on Porter Run southwest of McCartney

	Ft.	In.
Coal, D, 1 ft. 6 in. to	2	
Interval, clay at top, shale at bottom	35	
Coal, C′	2	6
Shale and hidden	16	
Sandstone, medium and coarse-grained, buff	20	
Hidden	20	
Coal bloom, C	—	
Flint clay	2+	
Shale, light drab and drab	15	
Shale, fissile, black at bottom	30	
Coal, B	2	9
Clay	3	
Sandstone, shaly	10	

A comparison of the various sections shown on the stratigraphic chart (Plate II) gives a good idea of the variability of the rocks in this group. This variability is well shown by a comparison of sections 10 and 11 in two bore holes only one mile apart near Gazzam.

FREEPORT MEMBER

The Freeport member consists of the rocks from the top of the Upper Freeport coal to the top of the Upper Kittanning coal. It contains two or more important coal beds, each underlain by clay, limestone (locally), sandstone and shale. In exceptional instances the sandstone is lacking between the two principal coals and more frequently one or both of the limestones are lacking. The member as a whole has a thickness of about 100 feet.

The member will be described by considering in turn the more persistent coal, clay and limestone beds. They and the intermediate rocks will be described stratigraphically only. This description will emphasize such features as may aid in their recognition in the field. The beds of economic interest will be described in more detail under Mineral Resources.

Upper Freeport or E coal. The Upper Freeport or E coal at the top of the formation is one of the widely persistent and workable coals in this area. It ranges in thickness up to 6 feet, though usually less than 4 feet, and may be lacking. Usually it is a single bed. It will be described more in detail under Mineral Resources.

The Upper Freeport or E coal can be recognized stratigraphically by the fact that, except very locally, it is the highest workable bed in this quadrangle, and by the rocks associated with it. The rocks in this quadrangle overlying the E coal are usually fine-grained shales of an olive or yellowish-green cast, in contrast with the shales over the D coal, which are usually drab, dark gray, or blue. These shales locally grade above into a flinty shale, somewhat like flint clay. This feature has not been noted in the shales over the D coal. Limestone is much more common under the E than under the D, though a limestone occurs under the latter locally. A layer of flint clay underlies the Upper Freeport limestone in many parts of this area, but is seldom if ever found under the D coal. The E coal may be recognized in many places from its position relative to the B coal, as it lies about 200 to 225 feet above the B as compared with 150 to 170 feet for the distance of the D coal. These special features are aids to its recognition besides its general relation to the rest of the column. This bed may be recognized in certain areas by its internal structure, or by its relation to the D bed where that bed over a considerable area maintains a uniform section of benches and partings.

Upper Freeport clay. Under the E coal is almost invariably a clay, usually of fair thickness, from 2 to 4 feet at least. This appears to be the thickest regular clay in the quadrangle except that under the B coal. Lying between the coal and the underlying limestone, it seldom carries as much sand in its lower part as some of the other underclays of the group.

Upper Freeport limestone. Under the Upper Freeport clay a limestone occurs in some of the sections. It ranges from 1 or 2 feet up to 4 or 5 feet thick. This is the Upper Freeport limestone. It is shown in some of the sections, Plate II. The limestone crops out as fragments at places on the roads in association with the Upper Freeport coal, but as it was not seen at many points and does not appear in most of the drill holes, it is probably present only locally.

Bolivar fire clay. A flint clay occurs with the Upper Freeport limestone in a few places. Its exact relation to the coal and limestone was not clearly seen at any point. It probably is at the horizon of the flint clay long mined at Bolivar, Westmoreland County.

The space between this flint clay and the Lower Freeport or D coal is usually filled with shale, often containing one or more layers of sandstone. In places the whole interval is filled with sandstone. The shale is usually characterized by its dark color, often dark purple, in contrast with the olive-green of the shales over the E coal. The sandstone where present is in the position of the Butler sandstone of western Pennsylvania. The interval between the E and D coals ranges from about 20 feet to 60 feet.

Lower Freeport or D coal. The D coal is a variable bed, in places appearing as a single bed of good thickness, and elsewhere splitting into two separate beds. It shows a good thickness west of Curwensville and southeast of McCartney. In other areas in this district this coal is usually thin, barely over a workable thickness, but of such high grade as to repay working in places where less than 2 feet thick. The tendency of this bed to split is best shown in the Houtzdale quadrangle to the east of this area. Southeast of McCartney it shows a thickness of 5 feet 6 inches, overlain by 2 feet 2 inches of bone. At McCartney, less than a mile away, this coal appears to be in two beds, the upper 2 feet 8 inches thick and the lower 1 foot 11 inches thick, separated by 12 feet of sandstone and one foot of clay. The detailed stratigraphy of this coal will be discussed more at length under Mineral Resources.

The Lower Freeport clay and limestone underlie the Lower Freeport coal, though in this quadrangle that limestone has been recognized at only a few points.

Between the Lower Freeport and Upper Kittanning coals the interval is commonly sandy and locally contains the massive Freeport sandstone.

KITTANNING MEMBER

The Upper Kittanning coal is usually thin and, in comparison with the other coals, of little importance commercially. It is the top bed of the Kittanning member.

The strata between the Upper and Lower Kittanning coals most frequently are shales with some beds of sandstone and from one to four beds of coal. These coal beds usually are thin, though exceptionally and very locally workable. Over the Lower Kittanning coal is generally a bed of drab shale, 15 to 25 feet thick, in places overlain by a rider coal. In many places a sandstone overlies the rider coal, with a slight non-conformity between the sandstone and the underlying coal and shale. That is, erosion, following the laying down of this shale but preceding the deposition of the sandstones, in many places cut out the little rider coal and the intervening shale so that the sandstone rests on the Lower Kittanning coal or replaces some or all of it.

Lower Kittanning or B coal. The Lower Kittanning or B coal is one of the most persistent beds in this area, possibly equalling or excelling in this respect the Upper Freeport. Locally it is 4 feet or more thick, as near Irvona, but most of the sections indicate a thickness between 2 and 2½ feet. In many places it is a solid bed without a trace of parting and with the grain or vertical jointing extending the full thickness of the bed. In many places there appears below this persistent bench an irregular bench ranging in thickness from a few inches to 2 or 3 feet and separated from the main bench by from an inch or two to 9 or 10 feet. The B coal is almost everywhere underlain by a thick body of clay. The clay ranges from 2 to 20 feet in thickness, though usually it is 6 to 8 feet. Its variations in the Curwensville region are illustrated in Figure 9.

CLARION MEMBER

Clarion sandstone. The Vanport limestone, which in western Pennsylvania has such a widespread occurrence and is of such great value, is not found in this quadrangle. Usually the clay under the B coal lies on shales or on a sandstone which locally becomes very massive. This is the sandstone exposed in the Buffalo, Rochester & Pittsburgh Railroad cut near the station at Curwensville and in the cut on the New York Central Railroad at McGees. It is very massive near McGees and to the north and northwest of that point. From its stratigraphic position it is believed to be the Clarion sandstone.

Clarion flint clay. Flint clay is locally associated with the clay under the B coal, though none of it has been worked commercially in this area. It is exposed in cuts along the Pennsylvania Railroad between Curwensville and Clearfield and fragments of flint clay were noted at many points in the roads a short distance below the outcrop of the Lower Kittanning or B coal. This clay is supposed to be at the same horizon as the flint clay so abundantly exposed in Clarion County and typically in the streets of Clarion. Where exposed it usually shows as an irregular mass not following the bedding, and in most of this immediate area does not appear to be in sufficient quantity to be workable. Flint clay is found in this stratigraphic position over a wide area in western Pennsylvania, Ohio, and as far south as eastern Kentucky. East of the Curwensville quadrangle a flint clay at this horizon becomes of good workable thickness and quality and has been mined extensively.

Clarion and Brookville coals. The base of the Allegheny group is at the base of the Brookville or A coal or its underclay. This coal is well exposed around McGees, just west of Mahaffey, as in the railroad cut, where it has a thickness of 4 feet, and in the district to the northwest and west of that point. In general, it is overlain by the Clarion sandstone. A thin coal seen locally at the top of the sandstone probably represents the Clarion or A′ coal. It is possible also that one of the coals below the B coal in Figure 9 is at this horizon. It does not appear to be workable in most of this area.

Pottsville Series

The Pottsville series is of direct economic interest as the source of commercial fire clay and building stone. In its type locality in the anthracite field of Pennsylvania, the Pottsville has a thickness of 1,200 feet and contains many workable coal beds. In the Southern Appalachians it attains a thickness of 6,000 feet or more and forms all of the Coal Measures from Tennessee southward. In this area its thickness is unimportant by comparison, being less than 200 feet. The difference in thickness between western Pennsylvania and eastern Pennsylvania is due to the fact that in western Pennsylvania a land surface existed during all of early Pottsville time so that, instead of the early Pottsville rocks being deposited, the pre-Pottsville rocks were being eroded. Toward the end of Pottsville time western Pennsylvania sank enough to allow Pottsville waters to bring in deposits, resulting in the 150 to 200 feet of its rocks found in this region. As developed in Central Pennsylvania, the Pottsville consists of three members, the Homewood sandstone at the top, in this region often represented largely by shale; the Mercer group of rocks at the middle and the Connoquenessing sandstone at the bottom. As one result of the unconformity due to the period of erosion in early Pottsville time, the Pottsville sandstone in this area lies in places upon the Pocono, the second formation below the Pottsville. In places to the northwest of this area even the Pocono has been removed.

Thickness of Pottsville. The general character of the Pottsville is fairly similar throughout the quadrangle. Of the three members, the Homewood locally consists of one bed of massive cliff-making sandstone, as up Anderson and Little Anderson creeks. It usually weathers into large debris that hides all of the rocks that might be exposed in the same hillside. The upper part of the Pottsville, including all that is found in this region, has been called the Beaver River formation. Where the rocks below the Homewood are above drainage, the hilltop is generally capped by the Homewood, and the hill slopes are so covered with debris that the underlying rocks are nowhere well exposed. Because of this it has been difficult to determine the base of the series in this region and thus to determine exactly its thickness. Shales of Mississippian age crop out in the east bank of Anderson Creek near Bridgeport. Immediately east of this point the divide is 180 feet above the uppermost shales containing Mississippian fossils. The divide appears to be about at the top of the Pottsville. Just above the shales mentioned is a massive sandstone which may be part of the Pottsville. In any case, if the hilltop above be close to the top of the series, as estimated, the total thickness must be less than 200 feet and probably less than 180 feet.

Near the mouth of Potts Run on the Houtzdale quadrangle the supposed top of the Pottsville lies 180 feet above red shales of Mississippian age. North of the Curwensville quadrangle the highest shales found of recognized Mississippian age were from 170 to 180 feet below the Mercer fire clay, which is itself from 40 to 60 feet below the top of the Pottsville.

HOMEWOOD SANDSTONE

The Homewood sandstone is the most massive member of the Pottsville in this region and is fairly well exposed. It forms prominent cliffs along the Susquehanna River, below Lumber City and below Curwensville; also up Anderson Creek and Hughey Run. Good sections can be obtained near Curwensville. In almost all places this sandstone is coarse-grained and in many is conglomeratic. Usually

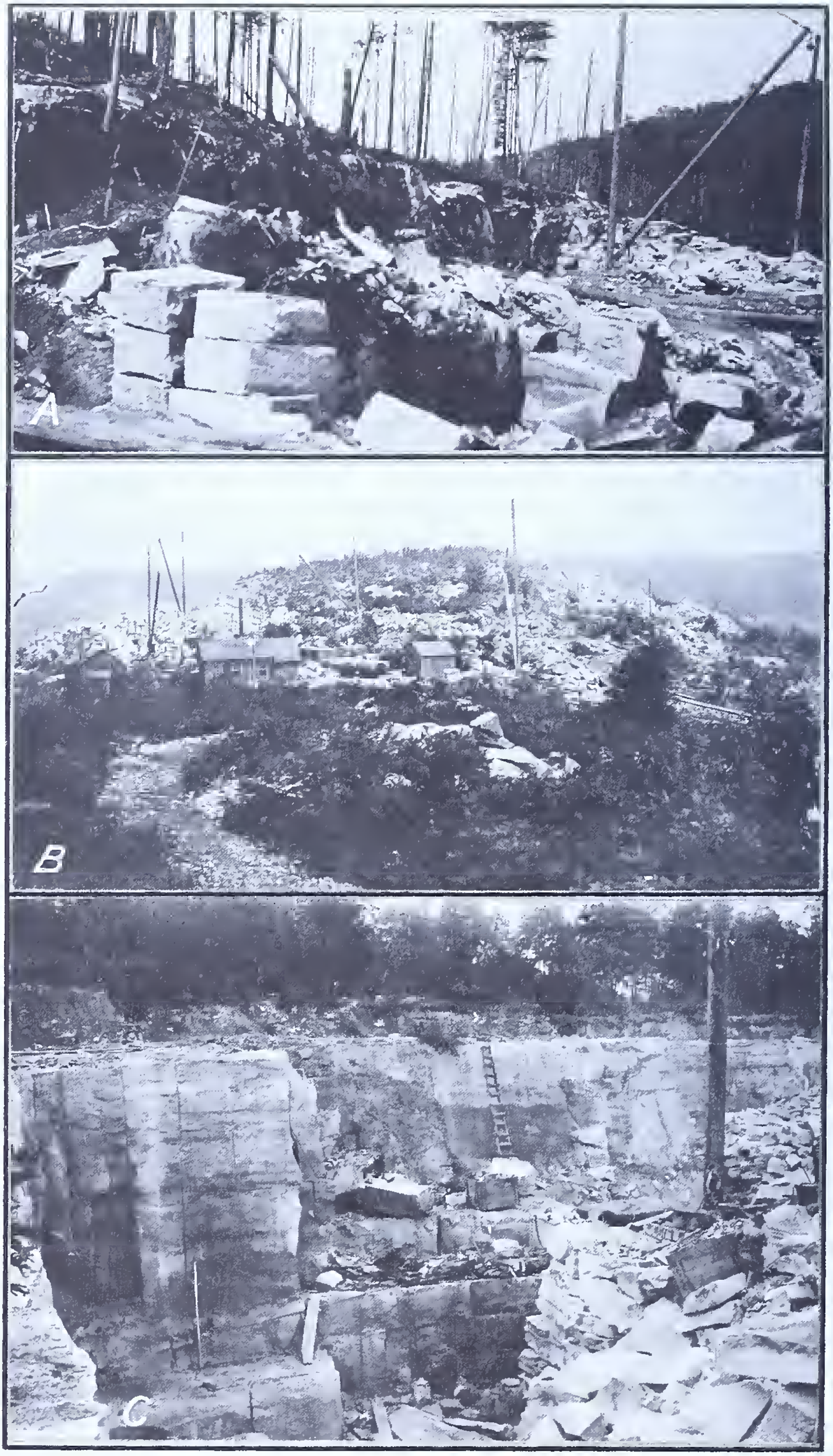

Figure 11. Sandstone quarries, Curwensville district.

A. Small quarry in Clarion sandstone at Chest Falls.

B. Conemaugh quarries, just north of quadrangle on Anderson Creek.

C. Roaring Run quarry.

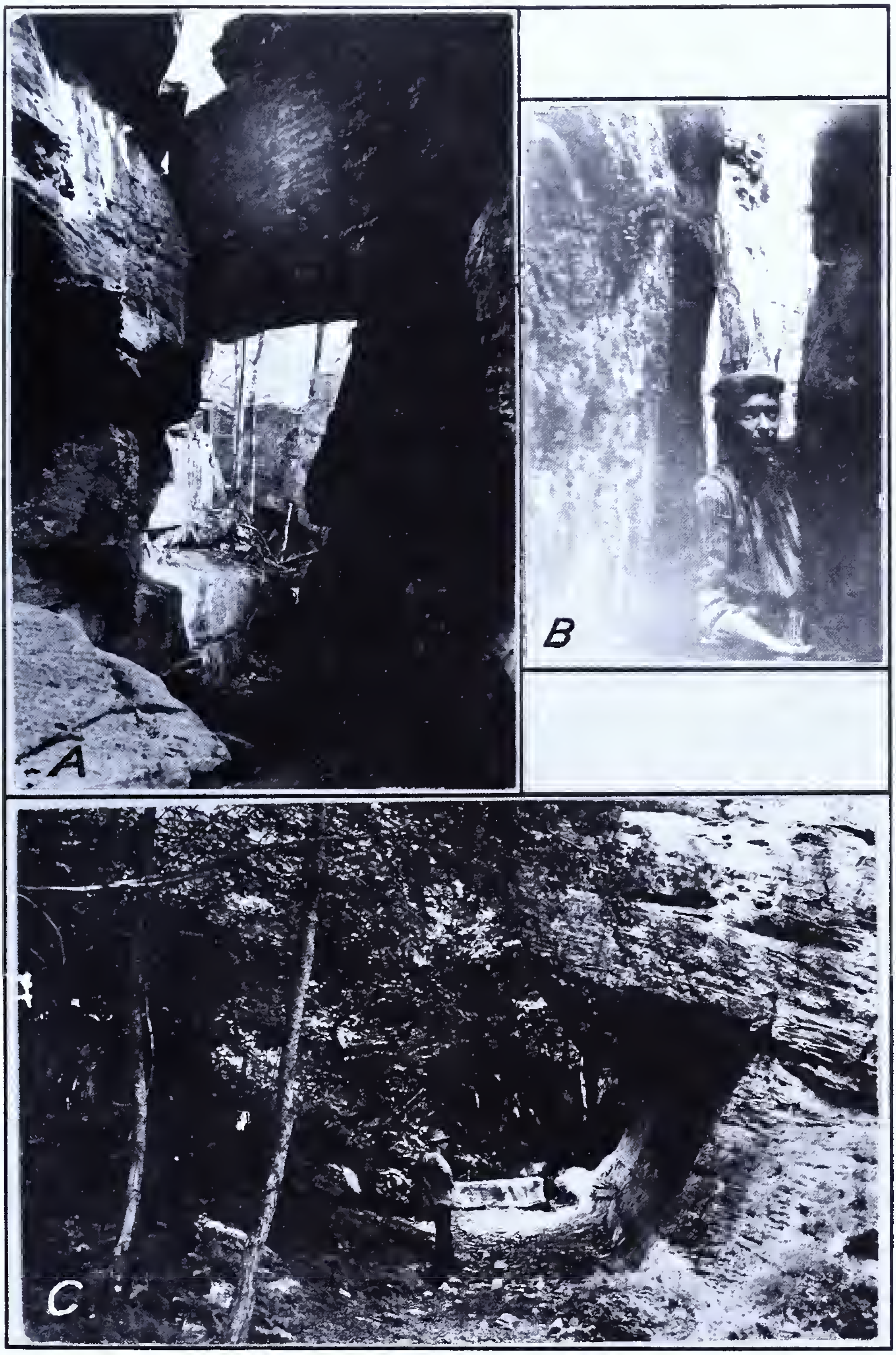

Figure 12. Views at Bilgers Rocks.

A. Characteristic passage.
B. Narrow passage connecting one "room" with another.
C. Entrance to rocks.

it has a light brown color. In some quarries the color is fairly uniform, but generally it is streaked or flecked with iron oxide in shades of brown. In its coarser facies the Homewood sandstone contains pebbles of quartz up to one inch or more in diameter. Locally it may be largely replaced by shale. In many places it is less massive than the overlying Clarion sandstone and was confused with that sandstone in much of the earlier work.

Thickness. In some quarry faces the Homewood sandstone shows a thickness of 20 to 40 feet without bedding planes. As a whole, this member of the Pottsville appears to range from 40 to 80 feet in thickness and includes a single bed 30 to 60 feet thick. Near the Curwensville Fire Brick Company's mines the Homewood appeared to measure about 65 feet. On Bilgers Run, Anderson Creek, and near Bells Landing it is over 50 feet thick.

Distribution. The Homewood sandstone crops out all along the valley of West Branch of Susquehanna River below Bells Landing. It is above or just below water level south of Curwensville, but ascends Little Anderson Creek almost to Grampian, and Bilgers Run and Anderson Creek to the north edge of the map. On Bilgers Run, close to the second road crossing north of the mouth of Fenton Run, is a notable instance of a "rock city" formed by this sandstone. Although the sandstone here is not as thick as that forming the famous "rock city" near Olean, N. Y., the number of blocks is possibly greater. The rock crops out here in a single bed 20 to 25 feet thick. Local conditions have opened joint planes and separated the sandstone into large blocks. The amount of the separation ranges from a few inches to as much as 15 or 20 feet. The result is chambers with vertical walls 15 to 25 feet in height, connected by narrow passageways of the same height and from 15 inches to 3 feet in width. Some of these narrow passageways are 50 feet long. Although perhaps not so impressive as the Olean "rock city", Bilgers Rocks are easily reached and will be of interest to anyone.

The Homewood sandstone caps the hills near Anderson Creek and Roaring Run, making long cliffs and strewing the hillsides with great blocks. It crops out inconspicuously in the headwaters of Hogback Run and is just above the level of Little Clearfield Creek below New Millport. Heavy sandstone along Potts Run below Erhard may be the Pottsville sandstone, though the interval from its top to the calculated position of the Moshannon coal is less than to the north or east. It crops out along almost the entire length of Clearfield Creek within the Curwensville quadrangle; also slightly up the two Witmer Runs.

MERCER GROUP

Between the Homewood and Connoquenessing sandstones is an interval of shale, coal, and clay. The interval ranges from 6 or 8 feet up to 20 or more feet. This small group of strata expands greatly to the west and south and is of considerable economic importance. It is called the Mercer group and the same name is applied to its two coal beds in this area. In some places these coals are of importance, though they are usually less than two feet thick. Near McGees Station just west of Mahaffey the two coals have each a thickness of 10 or 12 inches. In a few other places one of these beds is 2 or 3 feet thick. In most places only one thin bed is found, and is not mined even in connection with the valuable clay just below it. Between the bottom of the Homewood sandstone and the Mercer coal there is usually, but not always, some shale. In several places, the Homewood sandstone makes the roof of the Mercer coal.

Below the Mercer coal is usually found a bed of clay. This clay has proved locally to have large economic value. It is mined extensively along the Tyrone and Clearfield Branch of the Pennsylvania Railroad and at numerous other points in the northeast corner of the Curwensville quadrangle. It is believed to be at the same horizon as the well-known Mt. Savage fire clay of Maryland. This clay ranges in thickness up to 18 feet, with an average of 8 or 10 feet over large areas.

Distribution. The Mercer group in this quadrangle is possibly above drainage over a very small area in the channel of Susquehanna River at Chest Falls (just where the line between Bell and Greenwood townships crosses the river). It reappears about a mile below Bells Landing and remains above river level to the mouth of Porter Run halfway between Lumber City and Curwensville. Near Lumber City it reaches an elevation of nearly or quite 100 feet above river level. The group reappears at river level at the mouth of Anderson Creek. It rises rapidly and crops out near the Baltimore, Rochester and Pittsburgh Railroad at Curwensville between the two railroad tracks. It is still better exposed directly across Anderson Creek from Curwensville and above the level of the Baltimore, Rochester and Pittsburgh Railroad just west of where it crosses that creek. At this point the Homewood sandstone is very thin and its interval seems to be largely shale or clay. The outcrop of the group runs up Little Anderson Creek to above the clay works at Stronach and up Bilgers Run to the north edge of the quadrangle. Up the main valley of Anderson Creek it extends to the limits of the quadrangle, where its altitude is over 1,200 feet. It also extends up Roaring Run to the neighborhood of the Roaring Run quarries. Likewise it crops out over a small area in the headwaters of Hogback Run. Local folding may bring the Mercer group above Clearfield Creek between Coalport and Glen Hope, but it was not seen in that region.

CONNOQUENESSING SANDSTONE

The lowest member of the Pottsville in this region, the Connoquenessing sandstone, is but little known here. It is below drainage in much of the quadrangle and, where above drainage, is usually hidden by debris from the Homewood sandstone. It is seldom a cliff-maker and its exposures are mainly those found in cuts along the stream beds. From this it may be judged to be mainly a fine-grained sandstone, quite shaly in places, and which may locally be nearly or quite replaced by sandy shale.

Thickness. The total thickness of the Pottsville, as discussed in preceding paragraphs, was estimated to be between 150 and 200 feet in this region, probably less toward the southeast. As the two upper members of the Pottsville have a combined thickness of 50 to 80 feet, the Connoquenessing sandstone would appear to have a thickness of about 100 feet in this region, rather less than more. No exact measurement of its thickness could be obtained as at no point was its lower limit recognized.

Distribution. The Connoquenessing sandstone appears to be above the level of the Susquehanna River for several miles below Lumber City. Its elevation above river level within this distance is slight. Aside from this exposure, it appears to be confined to the valleys of Anderson and Little Anderson creeks. It appears in the bluffs just above water level at the mouth of Anderson Creek and probably extends a short distance up and down the river. It rises rapidly up Anderson Creek so as to crop out above the level of the railroads on the west side of the creek at the west end of the Curwensville bridge. It extends up Little Clearfield Creek to the clay works at Stronach and up Bilgers Run for about two miles. It crops out along Anderson Creek to the edge of the map, having a steady rise in that distance so that its upper surface at the northern limit of the quadrangle is not far from 1,700 feet above sea level.

MISSISSIPPIAN SYSTEM

The Mississippian system, or "Lower Carboniferous" of old reports, consists of two series in this area, the Mauch Chunk at the top, and the Pocono below. Both of these hitherto-called "formations" are here treated as "series" because recent studies make it appear that the Mauch Chunk shales and sandstones where intact represent practically all of the Upper Mississippian, and that the Pocono represents at least the lower half of Lower Mississippian. These studies have at the same time revealed a long time break between them, equivalent to most or all of Middle Mississippian and the upper part of Lower Mississippian.[1]

Mauch Chunk Series

Character and thickness. The Mauch Chunk series, which has a thickness of several thousand feet in the eastern part of the State, is but poorly represented in the Curwensville quadrangle. Its presence when exposed is generally recognized by the red color of the shales.

Just north of Bridgeport there are exposures of Mississippian rocks, consisting mainly of sandstones and sandy shales, of which probably the lower belong in the Pocono.

Section at bluff opposite Bridgeport

	Feet
Sandstone, massive, yellow	15
Interval, shows massive sandstone which probably came down from the preceding	15
Shale, drab, sandy, some black, fossiliferous	3
Sandstone, light brown and yellow, irregularly bedded	25
Shale, dark drab, sandy, fossiliferous (in places tending to grade into a shaly sandstone, very fine-grained, resembling a flint clay in its color, fracture, etc.)	15
Sandstone	

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[1] Butts, Chas., The Loyalhanna limestone of southwestern Pennsylvania: Amer. Jour. Sci., VIII, Sept., 1924.

The fossils contained in the two principal shale beds are identified by David White as of Mississippian age. The massive sandstone at the top of the section may be the bottom of the Pottsville sandstone, in which case part or all of this section may be of Mauch Chunk age, notwithstanding the fact that no red shales were seen. On the other hand, if the massive sandstone at the top of the section does not belong in the Pottsville, the Mauch Chunk may lie entirely above the section and may contain red shales, as it appears to do a little farther up Anderson Creek. In the latter instance all or part of the rocks here exposed may be of Pocono age. The sandy facies of the lower shale has been drifted upon near Bridgeport, possibly under the impression that it was flint clay.

Farther up Anderson Creek, beyond the limits of this map, a mere trace of red clay which was thought to mark the top of the Mauch Chunk shales was detected near a line of springs. It was reported later that a drill hole a few feet above one of the springs showed 5 or 6 feet of red shale. From the position of this red shale relative to the Mercer clay, which was being worked almost immediately above the spring, it would seem that, if the Mauch Chunk is in this region at all, this red shale probably is it.

Shales and sandstones on Potts Run, near Boardman, a short distance from the eastern edge of this quadrangle, are believed to belong in the Mauch Chunk series, so it seems probable that the Mauch Chunk is present in the valleys of Anderson and Little Anderson creeks, though the debris from the Homewood sandstone leaves little opportunity for the outcrop to be observed or studied.

In general, the laying down of the Mauch Chunk in this part of Pennsylvania was followed by emergence, during which large parts of that series were removed by erosion. The series appears to be lacking in the western part of the Punxsutawney quadrangle, and it is possible that drilling in the northwest corner of the Curwensville quadrangle may show it lacking there, even though present in Anderson Creek valley. Its outcrops are confined to the valleys of Anderson and Little Anderson creeks. The outcrop appears a short distance below Bridgeport, and goes up Little Anderson Creek, keeping near creek level and passing below drainage near the mouth of Bilgers Run. It continues up Anderson Creek, getting higher toward the north edge of the quadrangle, where it occurs between 100 and 150 feet above the creek.

Pocono Series

The Pocono, which, in this region, constitutes the lower part of the Lower Mississippian, is the lowest formation recognized as outcropping in this area. The series is named from the Pocono (mountains) Plateau in the northeast part of the State where the sandstone, of which it is there mainly composed, laps up on the western edge of the plateau. It was formerly thought to underlie all of the plateau. In the type locality the series is mostly coarse sandstone and conglomerate, but toward the south and west it becomes more complex, consisting of interbedded shale, sandstone, and conglomerate. Along the Allegheny Front, to the south of this quadrangle, the Pocono series has a thickness of 1,100 feet, the upper 400 feet of which is sandstone (the Burgoon) and the lower 700 feet shale and sandstone. Some of the shale is red.

In the Curwensville quadrangle the Pocono crops out only in steep hillsides along Anderson and Little Anderson creeks. At a few points along Anderson Creek fairly massive sandstone 10 to 20 feet thick forms bluffs at creek level. The general character of the Pocono in this area, however, must be determined from drill records or from outcrops along the Allegheny Front and Allegheny River. In the valley of Allegheny River the formation consists of 250 feet of Burgoon sandstone at the top, 230 feet of Cuyahoga shale and limestone, a thin-bedded sandstone, 160 feet of blue shale, down to the Berea grit or sandstone which is at or near the base. As thus described, it has a total thickness in that region of 700 feet or more.

In this quadrangle, which is intermediate between the two areas mentioned, the Pocono would be expected to have an intermediate character and thickness. That is, the red shales of the Allegheny Front, which have disappeared before the Allegheny River is reached, are still red in this region. The upper or Burgoon sandstone may be expected to occur with an intermediate thickness of 300 to 350 feet. In the few places where the series can be seen it shows red shale, olive shaly sandstone with some drab and black shale, and gray sandstone. These rocks were not seen in any place in connected outcrop so as to yield a continuous section. Therefore, our knowledge of the section as a whole, or the relative importance of the various rocks mentioned, is quite limited.

Distribution. In this quadrangle the rocks referred to the Pocono series are exposed only in the valleys of Anderson and Little Anderson creeks, but doubtless underlie all of the quadrangle. The outcrop is very limited in the latter and in the former is confined to the portion of the creek from about a mile above Curwensville northward. Toward the edge of the quadrangle it is possible that the whole thickness of the upper or Burgoon phase may be represented in the banks of the creek. Practically the only outcrop seen of the red shale, which is probably to be included in the Pocono, is exposed in a cut along the Buffalo, Rochester & Pittsburgh Railroad about 1 mile south of the northern edge of the quadrangle. A section at this point shows about 23 feet of chocolate-colored shale, of which the middle 3 feet is sandy.

Rocks Not Exposed

Below the rocks exposed at the surface in this quadrangle are many thousands of feet of other sandstones, shales, and probably limestones, underlain by schists or granites or rocks of that general type. How many feet of these rocks there are can only be estimated from deep drillings west and south of this area, and from the rocks brought up east of this area by the intense folding prevalent in central Pennsylvania and exposed by erosion. The bedded rocks in east-central Pennsylvania are indicated to have a thickness of 25,000 or 30,000 feet. The same rocks in the northwest corner of the State are estimated to have a thickness of only about 8,000 feet. In the Curwensville quadrangle they may be assumed to have a thickness of close to 25,000 feet, of which over 8,000 feet have been pierced by the drill just west of the northwest part of the quadrangle. One deep drill hole in this quadrangle has gone through 2,761 feet of rock, of which about 2,000 feet lie below the rocks exposed at the surface. A log of this hole is as follows:

Log of gas well near Hepburnia, in feet

	Thickness	From	To
Coal	6	102	108
Coal	3	130	133
Lime	10	160	170
Coal	3	242	245
Coal	4	290	294
Coal	23	370	393
Big Injun sand	354	400	754
Slate	12	754	766
Red rock, "Patton," Meadville	64	766	830
"Murrysville" sand	30	1,100	1,130
"Hundred foot" sand	105	1,270	1,375
"Third" sand	12	1,718	1,730
Sand	65	1,931	1,996
"Speechley" sand	24	2,266	2,290
"Tiona" sand	15	2,425	2,440
Sand	61	2,450	2,511
"Sheffield" sand	62	2,640	2,702
Total depth			2,761

In this well log, 354 feet of sandstone may be the same as the Burgoon, which the drillers call the ''Big Injun.'' The 74 feet of red rock from 766 to 830 is probably the Patton red shale, found widely at the base of the Burgoon. Below that, certain sandstones have been identified with well-known productive ''sands'' of the oil and gas fields of western Pennsylvania. Whether these correlations are correct cannot be determined until more drilling has been done in the intermediate area. In view of the general thickening of the rocks from west to east, it would seem likely that sandstones under this region would thin out before reaching western Pennsylvania, or that at least little credence could be put on definite correlation between the two areas. In any case, it would appear that the intervals from recognized rocks at the surface to any given oil and gas sand would be considerably greater in central Clearfield County than in Butler or Venango County. The record is given here for what it is worth, but with the caution that the suggested correlations may prove erroneous. It is suggested that the sand from which gas was obtained at 2,685 is more likely to be the Speechley sand than one of the higher sands.

All of these rocks from the base of the Murrysville sand at 1,130 feet are of Devonian age. As the Devonian has a thickness of 7,500 feet or more in east-central Pennsylvania, it is probable that this well reaches only into the upper part of the Upper Devonian, stopping in rocks of ''Chemung'' age. If that surmise is correct, there should be found at greater depth the dark shales of Portage age, black shales of Genesee age, shales and sandstone of Hamilton age, dark shales of Marcellus age, limestone of Onondaga age, sandstone or limestone of Oriskany age, and limestone of Helderberg age. Still below these will be several thousand feet of Silurian rocks and many thousand feet of Ordovician, Canadian, and Cambrian rocks.

Since the above was written, the discovery of large volumes of gas in northern Pennsylvania in the Oriskany sandstone leads to the question of the depth of that sandstone under this quadrangle. Its depth can be approximated only by interpolation from known rock thicknesses in adjacent areas. The log of a well just west of this quadrangle indicates that the interval from the top of the Pottsville to the top of the Oriskany is about 6,900 feet. The same interval on the Allegheny Front near Altoona is 8,300 feet and near Lock Haven 8,200 feet. The center of this quadrangle lies about half way between the well first mentioned and a point between Altoona and Lock Haven. Computed in this way, the depth indicated from the top of the Pottsville to the Oriskany in this quadrangle is about 7,500 feet. The Tuscarora sandstone should be found 2,000 to 2,500 feet deeper.

AREAL AND STRUCTURAL GEOLOGY

What the map shows. The areal geology map shows what rock or group of rocks immediately underlie the surface at any point, or what part of the surface is underlain by any rock or group of rocks. The structure contours show the lay or position of the Upper Freeport coal with reference to sea level and the surface. With this information, and the topographic map, and a knowledge of the thickness of the rocks, it is possible to determine the depth to any rock stratum, coal bed, or gas sand.

The areal map. In general, the area underlain by any rock layer is determined by: (1) the shape of the surface of the country; (2) thickness of the rocks; (3) the structure or position of the rocks with reference to a level surface.

The rock underlying any point on the map may be determined by noting the color pattern on the map at that point and comparing with the color pattern in the explanation on the side. Such a comparison may not show exactly whether the underlying rock is shale or sandstone, as, in this area, the shales and sandstones vary so in thickness and extent that to have determined them accurately for every point would have increased the cost of the work many times over and, had these rocks been determined, they could not have been shown in many parts of the map because of its small scale; for a band of shale 10 feet wide on a hill slope would have to be shown on the map by a band only 1/520 of an inch wide. The attempt has been made to show the distribution of the more massive sandstones. If, by means of the structure contours to be described, it be determined about where in the columnar section the surface is, it may often be possible to approximate what the rock underlying the surface is most likely to be. For example, if it be found by the topographic map that the surface lies at 1,620 feet and by the structure contours that the top of the Upper Freeport coal is about at 1,480 feet, or 140 feet below the surface, a comparison of the stratigraphic sections will show that the rock immediately under the surface comes within 20 feet above the Brush Creek coal and, as shown by the sections, is most likely to be a sandy shale such as is exposed in the railroad cuttings all about Punxsutawney. If in this case the top of the Upper Freeport coal had been found to be about 90 feet below the surface, it might be assumed with much probability that the underlying rock was a sandstone, because in this area, at 90 feet above the Upper Freeport coal, is usually found the Upper Mahoning sandstone. In any case the character of the rock at the surface can usually be determined by a very slight amount of digging or may be judged by the character of the soil. If that be a loose sand, it may be assumed that the underlying rock is a pure sandstone. If it be a sticky clay, it is likely that the underlying rock is a nearly pure shale or possibly a limestone; if it be, as it will commonly prove, a sandy clay, it is probable that the underlying rock will be found to be a sandy shale or a shaly sandstone, the two rocks grading into each other.

Structure

Broad features. The geologic structure of the Appalachian coal field is very simple, consisting, in a general way, of a broad, flat, canoe-shaped trough. This is particularly true of the northern extremity. The deepest part of the trough is along a line extending southwest from Pittsburgh across West Virginia. On the southeastern side of this axis the rocks dip to the northwest, and on the northwestern side they dip toward the southeast. About the canoe-shaped northern end the strata are exposed in rudely semicircular lines of outcrop, and generally dip toward the lowest part of the trough, which is in the southwest corner of the State. Although the structure of the region has this general simple character, the eastern limb of the trough is crumpled into parallel wrinkles or folds that make the details somewhat complicated and break up the regular western dip of the rocks so that at first sight it is not apparent. Close examination, however, shows that in general from the Allegheny Front westward each succeeding trough is deeper than the one on the east, and that the arches are correspondingly lower until beds that have an altitude of over 2,000 feet at the Allegheny Front extend below sea level in the central part of the basin. In describing these folds, the arch is called an anticline and the trough is called a syncline. The axis of a fold is that line which at every point occupies the highest part of the anticline, or the lowest part of the syncline, and from which the strata dip in the anticline, and towards which they dip in the syncline. Geologic structure is represented graphically by structure contours which depict the altitude of the Upper Freeport coal throughout the area.

Structure contours. In order to represent the altitude of the strata at all points, structure contours are used. Some pronounced and persistent stratum in the region is selected as a key rock. The top or bottom of this bed is called the datum surface. For this quadrangle the bottom of the Upper Freeport coal has been selected. The form of this surface is ascertained, first, from observations of the elevation of its outcrop; second, from its depth below the surface as correlated from the higher rocks that are exposed; and third, from its former position where it has been removed by erosion, as calculated from the underlying beds now at the surface.

In the first instance the stratum crops out and the altitude of the datum surface is determined by observation either by transit level, hand level, or barometer. In the second, the datum is underground, and its position is calculated by subtracting from the surface altitude the thickness of the intervening beds that separate the datum surface from the rocks observed in outcrop. In the third case, the datum surface is "in the air," that is, it has been eroded away and its position is determined by adding to the surface altitude the estimated thickness of the beds that intervene between the stratum showing in outcrop and the datum surface, this estimate being based upon the interval actually found between the beds as seen elsewhere.

From the topographic map can be ascertained the approximate altitude of any outcrop, and thus the height above sea level of a corresponding point on the datum surface. In this manner the altitude of hundreds of points of the datum surface have been obtained in this quadrangle. Points having the same altitude are then connected by a contour line which gives the form of the datum surface at that altitude. If such lines are drawn at regular vertical intervals, they show the horizontal contours of the troughs and arches; the dip of the beds, and the depth of the datum surface below, or its height above the surface at any point.

The accuracy of the structure contours varies from place to place, depending upon local conditions. Where the altitudes of the outcrops have been ascertained by spirit level, the positions of the contours are well determined. This is especially true where mines have been operated upon the reference bed, as they have in this area on the Upper Freeport bed.

In most areas a determination of the position of the contours is subject to slight errors, caused by the inaccuracies of the base map, inexact altitude of the datum, and the possible errors in correlation. In the Curwensville quadrangle especially, the conditions for determining geologic structure are extremely unfavorable owing to the lack of outcrops, coal mines, drill holes, and key rocks. On account of these conditions in some areas in the Curwensville quadrangle, uncertainty exists as to the exact structure, and correspondingly as to the position of the several stratigraphic units.

This quadrangle has only one pronounced structural feature, the Chestnut Ridge anticline, which crosses the northwest corner. The Laurel Hill anticline enters this quadrangle at the center of the south line, but loses strength rapidly toward North Witmer Run. After crossing North Witmer Run, it or a new anticline continues northeastward across Clearfield County. Between these anticlines is a broad basin, which appears to be very flat in the center of the quadrangle. Toward the northeast this develops into a marked syncline, which for a distance coincides with the valley of the Susquehanna River. To the southwest it appears to break up into gentle synclines and anticlines of rather indefinite extent. Southeast of Irvona the dips are southeastward into the broad Houtzdale basin. Northwest of the Chestnut Ridge anticline the rocks dip steeply to the Punxsutawney syncline.

Chestnut Ridge anticline. A pronounced structural feature in the Curwensville quadrangle was called the Driftwood anticline by the old Survey, and was connected up with the Chestnut Ridge anticline of southwestern Pennsylvania. It is known now by the latter name. Topographically this anticline produces the highest ground in the quadrangle, the land near Rowles rising above 2,200 feet. The axis crosses the northwest corner of the quadrangle in the headwaters of Curry Run. In this area the Upper Freeport coal is lifted to 2,100 feet above tide. The anticline decreases slightly in altitude northeastward. Where it enters the quadrangle west of Rowles the surface both along the axis and the flanks of the anticline is capped with the Upper Mahoning sandstone. In this region the sandstone is both massive and coarse-grained, and hilltop is thickly strewn with its huge boulders.

Though the axis of the anticline leaves the quadrangle 4 miles to the northeast, the southeastern limb of the anticline takes an easterly direction across the northern part of the quadrangle as far as or a little beyond Grampian, then turns northeast again to the northeast corner of the quadrangle. The axis of this anticline, after crossing the northwest corner of the Curwensville quadrangle, appears to turn sharply to the east for several miles. The dip in the northeast corner of the quadrangle is locally 300 to 350 feet to the mile.

Clearfield, Brush Valley and Barnesboro synclines, and Nolo anticline. The Clearfield syncline is the continuation of the Brush Valley and Barnesboro synclines which exist only at the south, separated by the Nolo anticline. They represent the "Second Basin" of the Rogers' Survey of Pennsylvania. In the northeast corner of the Curwensville quadrangle, the Clearfield syncline is distinct and fairly narrow, the Upper Freeport coal having an elevation of about 1,400 feet. That coal rises to the northwest past Curwensville to 2,000 feet on the Chestnut Ridge anticline, and in an opposite direction to 2,150 feet on the Laurel Hill anticline at the southeast. The syncline becomes less deep to the southwest and widens near Lumber City, dividing around a slight anticlinal knob. The coal here is at about 1,500 feet above sea level. The anticline to the southeast breaks down from 2,200 for the Upper Freeport coal in the north-central part of the Houtzdale quadrangle on the east, to 1,600 feet in the southeast part of the Curwensville quadrangle. Along the west side of the Curwensville quadrangle, the structure has a rolling aspect with a low area northeast of La Jose, and a high knob to the northwest. Just west of Mahaffey, however, a distinct syncline begins to show. Extending southwestward, it rapidly carries the Upper Freeport coal down to below 1,250 feet at the south line of the Punxsutawney quadrangle. The axis passes just southeast of Burnside.

Another syncline occurs near the eastern edge of the basin, south of the center of the Curwensville quadrangle, which carries the E coal down to 1,450 feet a little north of Westover. The first of these two synclines becomes the Brush Valley syncline of Cambria County and the other the Westover or Barnesboro syncline. The Nolo anticline, between the two synclines, which is very slight at the southwest corner of the Curwensville quadrangle, becomes more pronounced to the southwest, raising the rocks 400 to 600 feet above their position in the two adjoining synclines.

Laurel Hill anticline. The Laurel Hill anticline, which is very pronounced to the northeast and southwest, is very low and indistinct where it crosses the southeast part of the Curwensville quadrangle. Some doubt exists as to the correlation of the coals and rocks north and northwest of Irvona, so that the structure contours in the structural gap or saddle may be slightly in error. There can be little doubt, however, of the general form of the gap. The Lower Freeport or D coal has an altitude of about 1,650 feet at Irvona as against 2,150 along the axis to the northeast and southwest. This break is so pronounced that the anticline might well be considered as two distinct, slightly overlapping anticlines.

Houtzdale syncline. In the southeast corner of the Curwensville quadrangle the rocks have a gentle dip to the southeast, 50 feet to the mile or less, into the Houtzdale syncline, the axis of which lies several miles farther southeast.

Distribution of rocks over the quadrangle

The geologic map shows that in the northwestern corner of the quadrangle west of Curry Run only very small hilltops contain parts of the Conemaugh group. The hillslopes down nearly to creek level are underlain by the members of the Allegheny group. The Pottsville series crops out along the banks of Susquehanna River and extends up Haslett Run and Curry Run and up the lower part of the main tributaries of Curry Run, including Fryor, Irish, and Daily Runs.

The ridge between Curry Run and Bell Run contains large areas and thicknesses of Conemaugh rocks. The steep flanks of this divide down to Curry, Poplar and Bell Runs, are underlain by the members of the Allegheny group, with the Pottsville cropping out along the runs.

The divide east of Bell Run and many of the hilltops east of Grampian and Hepburnia are capped by small areas of Conemaugh rocks. Otherwise all the area between Bell Run and Anderson Creek is underlain by the Allegheny group except just along the main streams. The area north of Anderson Creek and Susquehanna River in the Curwensville quadrangle contains no Conemaugh rocks and only the lower part of the Allegheny group. The rapid rise of the rocks brings the Pottsville and underlying rocks to the surface along Anderson Creek and over broad areas east of the creek and up Hogback Run.

Nearly all the area west of Chest Creek is underlain with rocks of Conemaugh age, the Allegheny rocks cropping out only along the lower and middle flanks of the hills west of Chest Creek and along Deer Run. Rocks of Pottsville age crop out in the lower course of Chest Creek.

South of Susquehanna River and east of Chest Creek the uplands in general are underlain with rocks of Conemaugh age and the lower slopes with rocks of the Allegheny group. Pottsville rocks occur on the river, on Little Clearfield Creek, and around Irvona. In the southeast corner of the quadrangle the Laurel Hill anticline brings the rocks up so that the areas of Conemaugh rocks capping the hills are narrower and the exposures of Allegheny rocks cover a much larger part of the valley slopes.

For details see the map.

MINERAL RESOURCES

The economic geology of a region considers what rocks, minerals, or soils of actual or potential value, occur in the region, their character, quality, thickness or volume, and their distribution horizontally and vertically. This quadrangle contains coal, plastic and flint clay, sandstone, shale, and limestone, their relative worth at present being in the order named. There are several beds of each, some of which, however, do not give promise of immediate value. The succession of beds is shown on the stratigraphic chart. A summary columnar section shows the more valuable beds and their positions relative to each other.

Table of rocks of possible economic value

Conemaugh group	Saltzburg sandstone
	Mahoning lower sandstone
Allegheny group	Freeport upper or E coal
	Freeport upper clay
	Freeport upper limestone
	Butler sandstone
	Freeport lower or D coal
	Freeport lower clay
	Freeport lower limestone
	Freeport sandstone
	Kittanning upper, or C′ coal
	Kittanning upper clay
	Kittanning middle or C coal
	Kittanning middle clay
	Kittanning lower or B coal
	Kittanning lower clay
	Clarion sandstone
	Brookville or A coal
Pottsville series	Homewood sandstone
	Mercer coal
	Mercer clay
	Connoquenessing sandstone

The character and quality of the several beds are considered in this chapter. The location and thickness of some of the beds are shown graphically on a set of resource charts, supplemented by sections and text descriptions.

The text gives for each resource the physical and chemical character, the thickness of the different beds, supplementing the data of the resources charts; an explanation of the geologic and resource map and how it is to be used. The resources are treated in the following order: coal, clay, shale, sandstone, limestone.

COAL

Physical character. The coal of this region is a soft bituminous coal of relatively high rank. The percentage of fixed carbon, especially of that on the eastern side of the area, places this coal in the medium volatile class but little below the rank of ''semi-bituminous'' coals. Most of the coal is long-grained; that is, the bed is cut by irregular vertical fracture planes and the coal in mining comes out in blocks or ''sticks'', which have their greatest length at right angles to the bedding. In many of the mines on thin beds the coal will mine out in ''sticks'' the whole thickness of the bed. The same is true of individual benches in some places where the coal is thick but occurs in benches separated by partings or binders. Under such conditions, it is not uncommon for one or more of the benches to be long-grained and others short-grained. The coal, as a rule, is tender, mining easily but breaking down readily in handling, yielding a large quantity of fine or slack coal. Most, if not all, of the coal is shipped as ''run-of-mine.'' A small quantity is sold for household use. The cleat or face is not strongly developed in the bed and many measurements made in this region failed to show any concordance in the direction of the cleat, which varies through the whole circle. The cleat becomes more pronounced toward the west. The coal, as far as noted, burns with a short, white flame. It is of the coking variety and probably all will coke.

Chemical character. The chemical character of the coal is shown in the following table of analyses, pp. 51-52: Column 2 is the laboratory number given each analysis by the Bureau of Mines; 3, the kind of sample. In this instance ''A'' means that the sample was obtained at the mine by an engineer of what was at that time the Technologic Branch of the Geological Survey, or of the U. S. Bureau of Mines; ''B'', that the sample was obtained at the mine by the author or by E. G. Hill, of this Survey. The fourth column shows the form of sample to which the analyses correspond as follows:

1. The sample as received.
2. As dried at a temperature of 105° C.
3. Moisture and ash free.
4. Moisture, ash and sulphur free.

Column 18 refers to the map location of the mine and 19 to the section on figures 15-25. The other columns are self-explanatory. The analyses are followed by descriptions of some of the samples.

Locality, mine, coal bed, etc.	Sample			Proximate				Ultimate					Air-drying loss	Calorific value		Softening temp. °F.§	References	
	Laboratory No.	Kind†	Condition	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen		Calories	Brit. ther. units		Section	Map
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Berwindale, ½ mile southeast of; Reed mine, Lower Freeport bed (face of room, 150 feet from 4 left entry, 1,400 feet southeast of mine mouth)	22,536	A	1	2.2	25.0	62.1	10.7	3.6					1.7	7,594	13,670	2,100	De16	103
Same (face of 4 left heading, 1,800 feet southeast of mine mouth)	22,535	A	1	2.8	25.7	62.6	8.9	3.0					2.1	7,672	13,810	2,100		
Same (face of 3 right back heading, 1,800 feet southwest of mine mouth)	22,537	A	1	2.9	24.2	64.1	8.8	4.3					2.2	7,672	13,810	2,260		
Same (face of 4 right heading, 2,200 feet northwest of mine mouth)	22,538	A	1	2.8	23.8	64.1	9.3	3.2					2.2	7,650	13,770	2,420		
Same (face of 4 right butt, 4 right heading, 1,800 feet northwest of mine mouth)	22,539	A	1	3.0	25.0	64.1	7.9	2.8					2.3	7,750	13,950	2,130		
Same (composite of samples 22,535 to 22,539 inclusive)‡	22,540	A	1	2.9	24.7	63.3	9.1	3.5	4.9	77.0	1.3	4.2	2.1	7,661	13,790			
			2		25.4	65.3	9.3	3.6	4.7	79.3	1.3	1.8		7,883	14,190			
			3		28.0	72.0		3.9	5.2	87.4	1.5	2.0		8,694	15,650			
Blain City, ¼ mile east of; Irvona No. 5 mine, Lower Kittanning bed (3 pillar, to right in "Peacock" section)	W17,058	A	1	2.2	21.0	69.3	7.5	1.1						7,872	14,170		Ff15	
Same (face of 3 room, Rosser heading)	W17,059	A	1	2.8	21.5	68.2	7.5	.8						7,828	14,090			
Same (composite of samples W17,058 and W17,059)	11,703	A	1	1.6			7.5	1.0	4.7	81.3	1.2	4.3						
			2				7.6	1.0	4.6	82.6	1.2	3.0						
			3					1.0	5.0	89.4	1.3	3.3						
Carnwath; Carnwath No. 1 mine, Lower Freeport bed (face of 7 room, 3 right entry, 75 feet from face of entry, 2,100 feet northwest of mine mouth)	20,342	A	1	3.0	24.3	65.0	7.7	1.6					2.4	7,772	13,990	2,460	Ed16	89
Same (face of 2 left entry, 1 left entry, 2,400 feet east of mine mouth)	20,343	A	1	3.3	23.9	66.7	6.1	1.4					2.5	7,856	14,140	2,390		
Same (composite of samples 20,342 and 20,343)	20,346	A	1	3.1	24.5	65.6	6.8	1.5	5.0	79.7	1.4	5.6	2.5	7,822	14,080			
			2		25.3	67.7	7.0	1.5	4.8	82.2	1.5	3.0		8,078	14,540			
			3		27.2	72.8		1.6	5.1	88.4	1.6	3.3		8,683	15,630			
Same (west rib of 1 room, 2 left back heading, 3,550 feet northeast of mine mouth)	20,494	A	1	3.5	24.5	66.1	5.9	.7					2.8	7,856	14,140	3,010		
			2		25.4	68.5	6.1	.7						8,144	14,660			
Same (1 crosscut, 2 room, 2 right heading, 2 left entry, 3,750 feet northwest of mine mouth)	20,495	A	1	3.7	23.9	66.1	6.3	.9					3.0	7,811	14,060	2,590		
			2		24.8	68.6	6.6	.9						8,667	14,600			
Same (west rib of 7 room, 1 right heading, 2 left entry, 3,700 feet northeast of mine mouth)	20,496	A	1	2.8	24.3	66.3	6.6	.9					2.0	7,850	14,130	2,670		
			2		25.0	68.2	6.8	1.0						8,078	14,540			
2½ miles southwest of; Carnwath No. 2 mine, Lower Freeport bed (20 feet from face of 6 right heading, 1,600 feet northeast of mine mouth)	20,338	A	1	2.6	25.6	64.3	7.5	2.6					2.0	7,794	14,030	2,270		
Same (crosscut, 5 room, 5 left heading, 1,200 feet northeast of mine mouth)	20,339	A	1	2.8	24.4	66.0	6.8	1.8					2.2	7,861	14,150	2,410		

Analyses of mine samples—Continued

Same (face of 6 room, 4 right heading, 1,200 feet southeast of mine mouth)	20,340	A	1	3.4	25.3	64.1	7.2	2.6					2.7	7,778	14,000	2,140		
Same (near face of 1 left heading, 700 feet northwest of mine mouth)	20,341	A	1	2.8	24.9	63.6	8.7	1.8					2.2	7,678	13,890	2,300		
Same (composite of samples 20,338 to 20,341, inclusive)	20,344	A	1	2.9	25.2	64.4	7.5	2.2	4.9	78.7	1.4	5.3	2.3	7,783	14,010			
			2		26.0	66.3	7.7	2.3	4.8	81.1	1.4	2.7		8,017	14,430			
			3		28.1	71.9		2.4	5.2	87.9	1.5	3.0		8,683	15,630			
Coalport, 2½ miles east of; Irvona No. 19 mine, Lower Kittanning bed (face of 2 right entry, main heading)	W17,056	A	1	3.0	21.0	68.0	8.0	.7						7,767	13,980			
Same (face of 10 face entry, 500 feet off 5 left entry)	W17,057	A	1	2.0	21.5	68.0	8.5	.8						7,822	14,080			
Same (composite of samples W17,056 and W17,057)	11,702	A	1	1.5			8.1	.8	4.7	80.9	1.2	4.3						
			2				8.2	.8	4.6	82.1	1.3	3.0						
			3					.8	5.0	89.4	1.4	3.4						
Curwensville, 1 mile south of; Addleman mine, Upper Freeport bed (face of main heading, 250 yards from mine mouth)	75,623	B	1	2.1	25.2	63.4	9.3	.7					1.3	7,728	13,910	2,850		
			2		25.7	64.8	9.5	.7						7,889	14,200			
1 mile southeast of Caldwell mine, Lower Freeport bed (face of 5 right heading, 3,000 feet from mine mouth)	75,619	B	1	2.4	23.1	67.8	6.7	1.0					1.7	7,900	14,220	2,450	Fa59	76
			2		23.7	69.4	6.9	1.0						8,089	14,560			
1½ miles south of; C. O. Norris mine, Lower Kittanning bed (face of main heading, 300 feet from mine mouth)	75,624	B	1															
			2	2.7	22.4	65.3	9.6	1.9					2.2	7,639	13,750	2,390		
Gazzam; Gazzam No. 1 mine, Lower Freeport bed (face of 9 left entry, 8,000 feet from mine mouth)	8,483	B	1	1.9	23.0	68.9	6.2	1.4	5.0	81.0	1.3	5.1	1.1	7,991	14,390		Ed21	86
			2		23.5	70.1	6.4	1.4	4.9	82.5	1.4	3.4		8,150	14,670			
			3		25.0	75.0		1.5	5.2	88.1	1.5	3.7		8,700	15,660			
Grampian, ½ mile west of; Grampian No. 3 mine, Lower Freeport bed (face of main heading, 500 feet from mine mouth)	8,482	B	1	4.1	23.0	66.8	6.1	1.9	5.2	78.5	1.1	7.2	3.2	7,778	14,000		Ca14	46
			2		24.0	69.6	6.4	2.0	5.0	81.8	1.2	3.6		8,111	14,600			
			3		26.0	74.0		2.1	5.3	87.4	1.2	4.0		8,667	15,600			
Irvona, ½ mile north of; Glen Brook No. 2 mine, Lower Kittanning bed (face of 6 left heading, 3,000 feet from mine mouth)	75,809	B	1	3.2	21.4	61.6	13.8	1.5					2.6	7,144	12,860	2,840	Ff32	
Same (face of room, 6 left heading, 3,000 feet from mine mouth)	75,810	B	1	3.2	22.1	60.6	14.1	1.5					2.6	7,133	12,840	2,740		
Same (composite of samples 74,809 and 75,810)	75,811	B	1	3.2	21.6	61.3	13.9	1.5	4.7	72.5	1.2	6.2	2.6	7,117	12,810			
			2		22.4	63.2	14.4	1.6	4.4	74.8	1.3	3.5		7,350	13,230			
			3		26.1	73.9		1.8	5.2	87.4	1.5	4.1		8,583	15,450			
La Jose, 1½ miles west of; Clearfield No. 1 mine, Lower Freeport bed (face of 5 heading, 1,700 feet southwest of mine mouth)	5,227	A	1	3.3	24.6	62.7	9.4	2.5					2.1	7,572	13,630		Bc7	65
			2		25.4	64.9	9.7	2.6						7,828	14,090			
Same (face of 5 room, 7 heading, 1,700 feet southwest of mine mouth)	5,233	A	1	3.3	23.7	65.1	7.9	1.4					2.1	7,728	13,910			
			2		24.5	67.4	8.1	1.4						7,994	14,390			
Mahaffey, ¼ mile south of; Mahaffey mine, Lower Freeport bed (100 feet from air shaft)	75,734	B	1	2.9	26.4	62.4	8.3	1.6					1.7	7,611	13,700	2,510	Ad6	
			2		27.1	64.4	8.5	1.6						7,833	14,100			

CURWENSVILLE. ADDLEMAN MINE

Analysis 75623. A mine 1 mile south of Curwensville, Pike Township, on the P. R. R. Upper Freeport coal. Thickness of bed, coal, and sample, 25 inches. Roof, slate; floor, fireclay. Cover at point of sampling (250 yards in at face of main heading), 50 feet. Sampled at one point by E. G. Hill on August 15, 1920. At the time of sampling the daily output was 20 tons.

CURWENSVILLE. CALDWELL MINE

Analysis 75619. Moshannon or Lower Freeport coal. Roof, slate; floor, fireclay. Cover at point of sampling, 60 feet. Sampled at one point by E. G. Hill on August 13, 1920.

Section of coal bed in Caldwell mine

Laboratory No.	75619	
	Ft.	In.
Coal	2	5
State binder		4
Coal		10
Thickness of bed	3	7
Thickness of sample	3	3

This section was measured at 5th right heading, 3,000 feet in. At the time of sampling the daily output was 300 tons.

CURWENSVILLE. NORRIS MINE

Analysis 75624. C. O. Norris mine, 1½ miles south of Curwensville, Pike Township, Lower Kittanning coal. Thickness of bed, 28 inches, and of coal and sample, 26 inches. Roof, slate; floor, fireclay. Cover at point of sampling (300 yards in at face of main heading), 40 feet. Sampled at one point by E. G. Hill on August 13, 1920, when the daily output was 25 tons.

IRVONA. GLEN BROOK No. 2 MINE

Analyses 75809 to 75811. A mine ½ mile north of Irvona, Beccaria Township, on the P. R. R. Lower Kittanning coal. Roof, sandstone; floor, fireclay. Cover at point of sampling 200 feet. Sampled at 2 points by E. G. Hill on August 28, 1920.

Sections of coal bed in Glen Brook No. 2 mine

Section	A		B	
Laboratory No.	75809		75810	
	Ft.	In.	Ft.	In.
Bone*		5		6
Coal	1	0		11
Sandstone*	1	2	1	1
Coal	3	0	3	0
Thickness of bed	5	7	5	6
Thickness of sample	4	0	3	11

* Not included in sample.

At the time of sampling the daily output was 120 tons.

MAHAFFEY. MAHAFFEY MINE

Analysis 75734. A mine ¼ mile south of Mahaffey on the P. R. R. Moshannon or Lower Freeport coal. Roof, slate; floor, fireclay. Cover at point of sampling, 30 feet. Sampled at one point by E. G. Hill on August 16, 1920. The daily output was 25 tons.

Section of coal bed in Mahaffey mine

Laboratory No.	75734	
	Ft.	In.
Coal	1	3
Slate binder		2
Coal	1	3
Thickness of bed	2	8
Thickness of sample	2	6

Coal beds

When they are considered as a whole, the coals of the Curwensville quadrangle are relatively thin-bedded, commonly without partings, though partings are characteristic of certain beds in certain districts, and generally characteristic of the C′ bed. All of this is shown in Figue 13, which gives average sections of the several coals by townships. This area is part of the "Thin-vein district" of central Pennsylvania. As indicated by the sections, the Lower Freeport, though not a thick bed, is the most persistent bed with minable thickness. Most of the coal averages less than 3 feet thick, and large areas are underlain by coal less than 2 feet thick. Shale forms the dominant roof, though locally replaced by sandstone. Practically all of the beds are underlain by clay, usually gray and fairly hard.

Upper Freeport (E) coal. The sketch map, Figure 15, shows the general distribution of the E coal. North of Susquehanna River, it underlies small areas on the crests of most of the interstream divides and many isolated hilltops. South of the Susquehanna River, the Brush Valley, Barnesboro and Clearfield synclines hold it low in the hills so that, although it occurs well above drainage, it underlies most of that area. Along most of the southwest edge of the quadrangle, it lies at some depth below the surface, cropping out at the east along Chest Creek. The E coal shows a general tendency to rise to the east; along the eastern edge of the area it occurs well toward the hilltops and in correspondingly smaller bodies.

The thickness, as shown by the shading of the sketch map, is variable and, on the whole, small, hardly averaging more than 2½ feet; and had more sections been obtained, the average probably would have been still further reduced. In considerable parts of the quadrangle, no measurable outcrops were found, nor were any prospects or coal banks open. In thinly settled areas this may mean only lack of local interest. In the better settled areas, the lack of open prospects or small mines doubtless means that the coal is very thin or wanting. This is especially true where not even coal blooms are found at the horizon of this bed over considerable areas, as is the case west of Chest Creek.

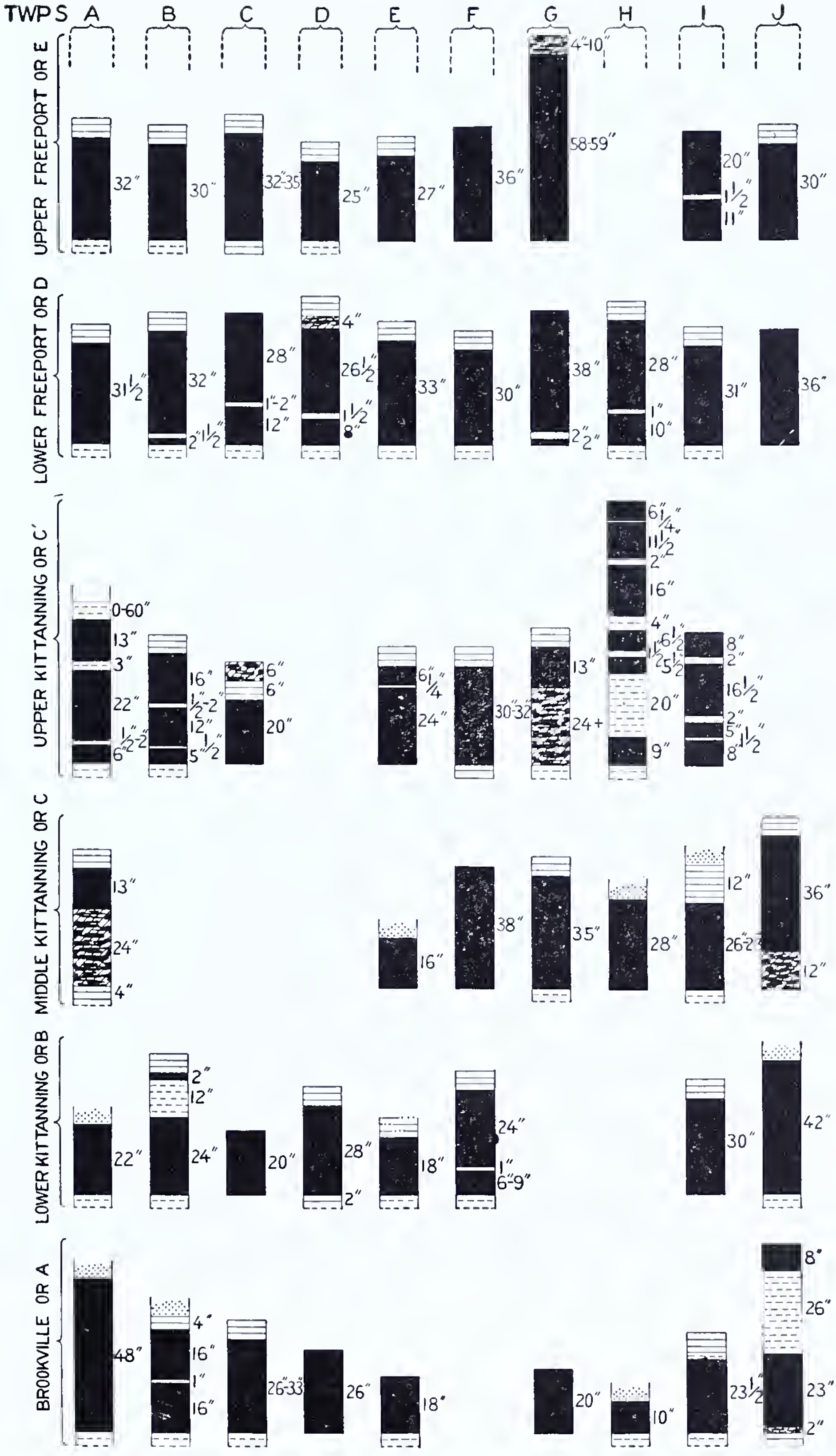


Figure 13. Sections of coal beds in Curwensville quadrangle.
Townships: A. Brady and Bell; B. Greenwood; C. Penn and Bloom; D. Pike; E. Ferguson; F. Jordon; G. Knox; H. Burnside; I. Chest; J. Beccaria.

In general, the E bed appears to be thicker but high in ash in the northwest corner of the quadrangle (sections 1, 2, and 6); less than 2 feet thick under the top of the divide between Curry Run and Bell Run (sections 3, 16, and 17). East of Bell Run and north of Susquehanna River, it is over 2 feet thick (sections 7-9, 11-13). South of Susquehanna River, the E bed appears to be over 2 feet thick north of Snyder Run and Little Clearfield Creek (sections 10, 14, 15, 18, 19, 24-27). In the area west of Chest Creek, and east of Chest Creek to the headwaters of Little Clearfield Creek and North Witmer Run, lack of openings or prominent coal blooms indicates that the E coal is very thin or wanting. At one place the section in that area is of fair thickness (sections 20-22). East of North Witmer Run and Little Clearfield Creek, the E bed appears to be everywhere over 2 feet thick and in spots the thickness is as high as 5 feet (sections 28-40).

Lower Freeport (D) coal. The D coal is the most important bed in this quadrangle. It is not a thick bed and but for its high quality would hardly be considered workable. It was being mined, when visited, presumably with financial success, at several places where it averages 3 feet or less. At one place, mining has been continued in many rooms to where the coal was only 17 inches thick. The evidence, although not conclusive, indicates that the D bed is split over part of the quadrangle and the thinness of the bed may be due in part to that fact. This condition is thought to hold over a considerable area on the east side of the quadrangle south of Little Clearfield Creek, when this quadrangle was studied, nearly all the commercial mines of the quadrangle, except those around Coalport and between Coalport and La Jose, were on this bed. In the northeastern part of the quadrangle, the bed is characterized by a parting over 2 inches thick, 2 to 12 inches from the bottom, a feature that holds over a considerable area to the east.

As shown by the sketch map, the D bed underlies the same area as the E but slightly extended, because it is under the E. In general, the D coal may be counted on as over 2½ feet thick, except where prospecting reveals areas of thinner coal. Locally, as west of Grampian and south of McCartney, it has a thickness of 4 to 5 feet.

Upper Kittanning (C′) coal. The C′ bed, locally referred to as the "dirty C", is characterized at many points by the number and thickness of its partings. The thickness of the bed has attracted attention and led to many small mines having been started on it in the hope that the partings would pinch out. A comparison of the sections suggests that the partings are more or less characteristic of the bed and may be expected to continue into the hill even though they do not continue regularly. Measurements at the St. Lu Mines near St. Lu show great variation in the thickness of the coal benches and partings from point to point. This bed has been opened on both sides of Chest Creek. At many of these places the Middle Kittanning (C) bed has been opened under the C′ and, as the lower bed is usually without partings, the association of the two beds assists in their recognition. The C′ bed will be expensive to work in this area because of the cost of separating the associated partings of shale and clay. Locally the partings are absent and it is possible that some areas of workable coal of good thickness exist, as around Berwindale.

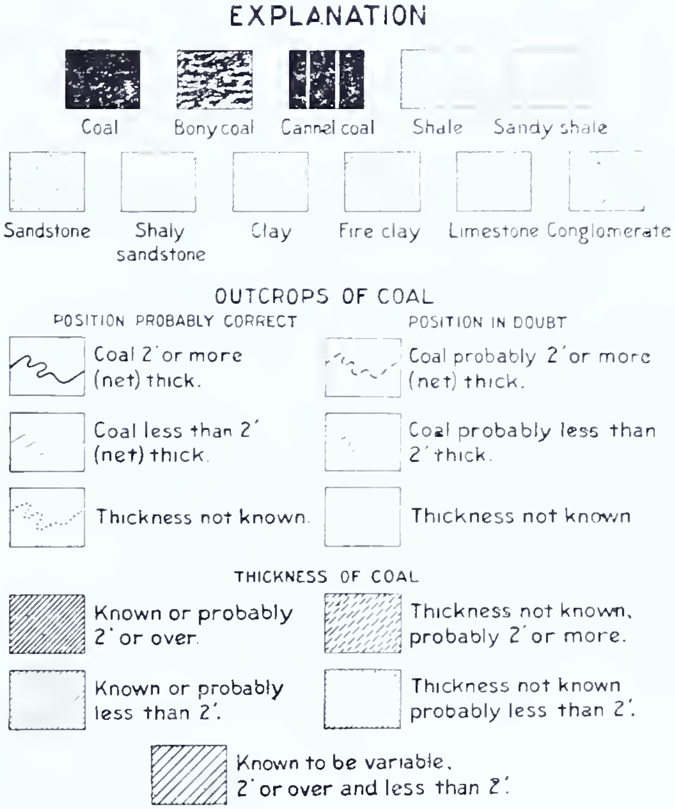

EXPLANATION
Coal
Bony coal
Cannel coal
Shale
Sandy shale
Sandstone
Shaly sandstone
Clay
Fire clay
Limestone
Conglomerate
OUTCROPS OF COAL
POSITION PROBABLY CORRECT
POSITION IN DOUBT
Coal 2' or more (net) thick.
Coal probably 2' or more (net) thick.
Coal less than 2' (net) thick.
Coal probably less than 2' thick.
Thickness not known.
Thickness not known
THICKNESS OF COAL
Known or probably 2' or over.
Thickness not known, probably 2' or more.
Known or probably less than 2'.
Thickness not known probably less than 2'.
Known to be variable, 2' or over and less than 2'.

Figure 14. Key to resource charts and sections which follow.

Note: Some of the township lines on the small maps (Figs. 15-29), based on surveys made in 1902, are not the same as on the engraved maps in the pocket. The latter are believed to be correct.

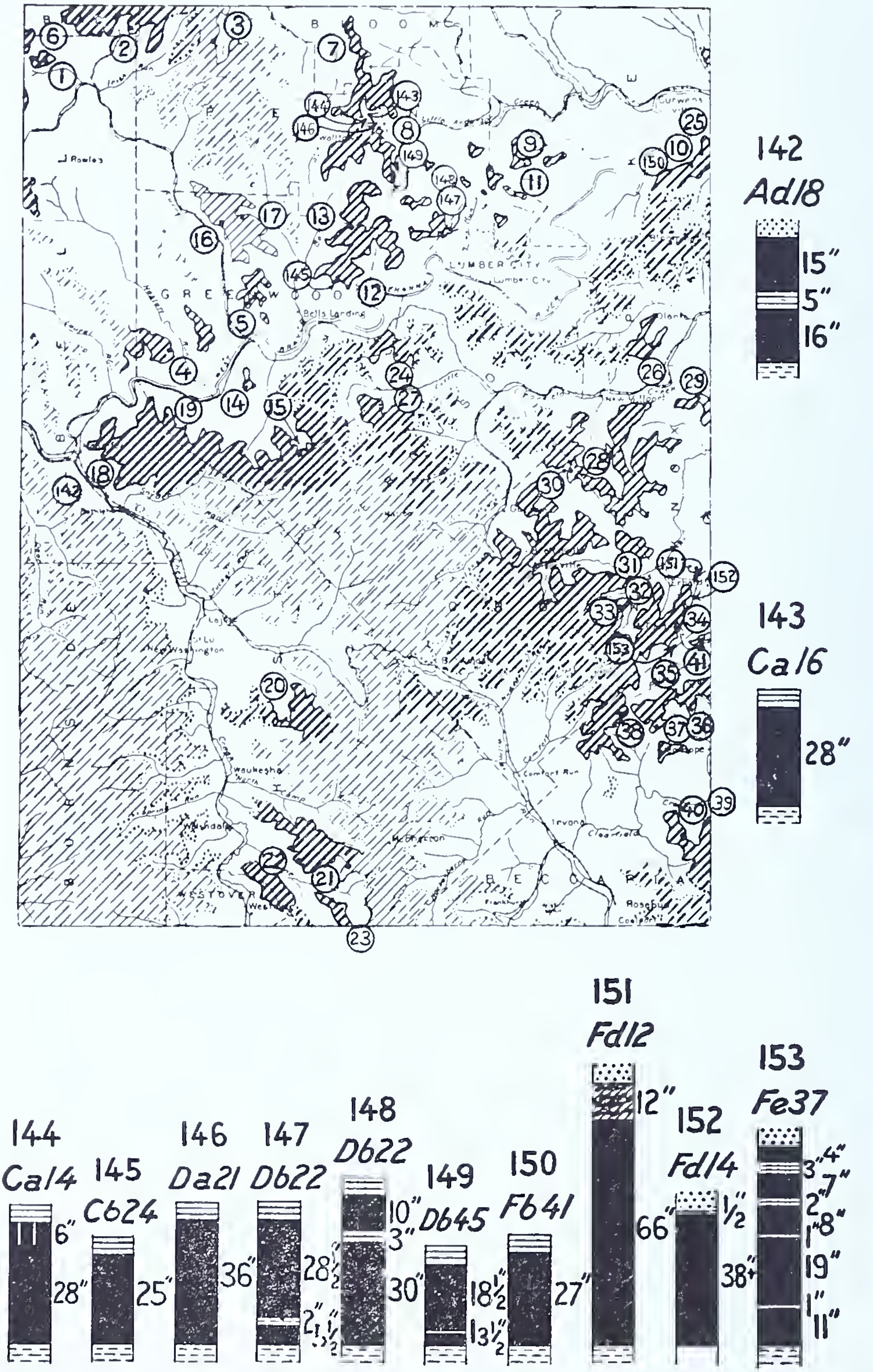


Figure 15. Map showing distribution and thickness of Upper Freeport or E coal, and location of sections. Also the following sections.

The numbers refer to the sections on this and the next figures. The letters and numbers are an index to the location of the sections on the mineral resource map; capital letters refer to the vertical columns of small quadrangles; small letters to horizontal columns, and the number to the exact location in the particular small quadrangle.

142	Ad18	Howard Mine (one-half mile south of Mahaffey).
143	Ca16	H. K. Colliery, near Grampian.
144	Ca14	Penn No. 3 B, west of Grampian.
145	Cb24	At Good No. 22A Mine, near Bells Landing.
146	Da21	Bell Run Mine (about 5 miles W. of Curwensville).
147	Db22	Apex Mine.
148	Db22a	Same, to show variation.
149	Db45	Curwensville Coal Company's Mine, south of Grampian.
150	Fb41	Rowles Station No. 2 Mine, south of Curwensville.
151	Fd12	Midvale No. 4 Mine at Erhard.
152	Fd14	Stripping, near Erhard.
153	Fe37	Witherow No. 1 Mine, near McCartney.

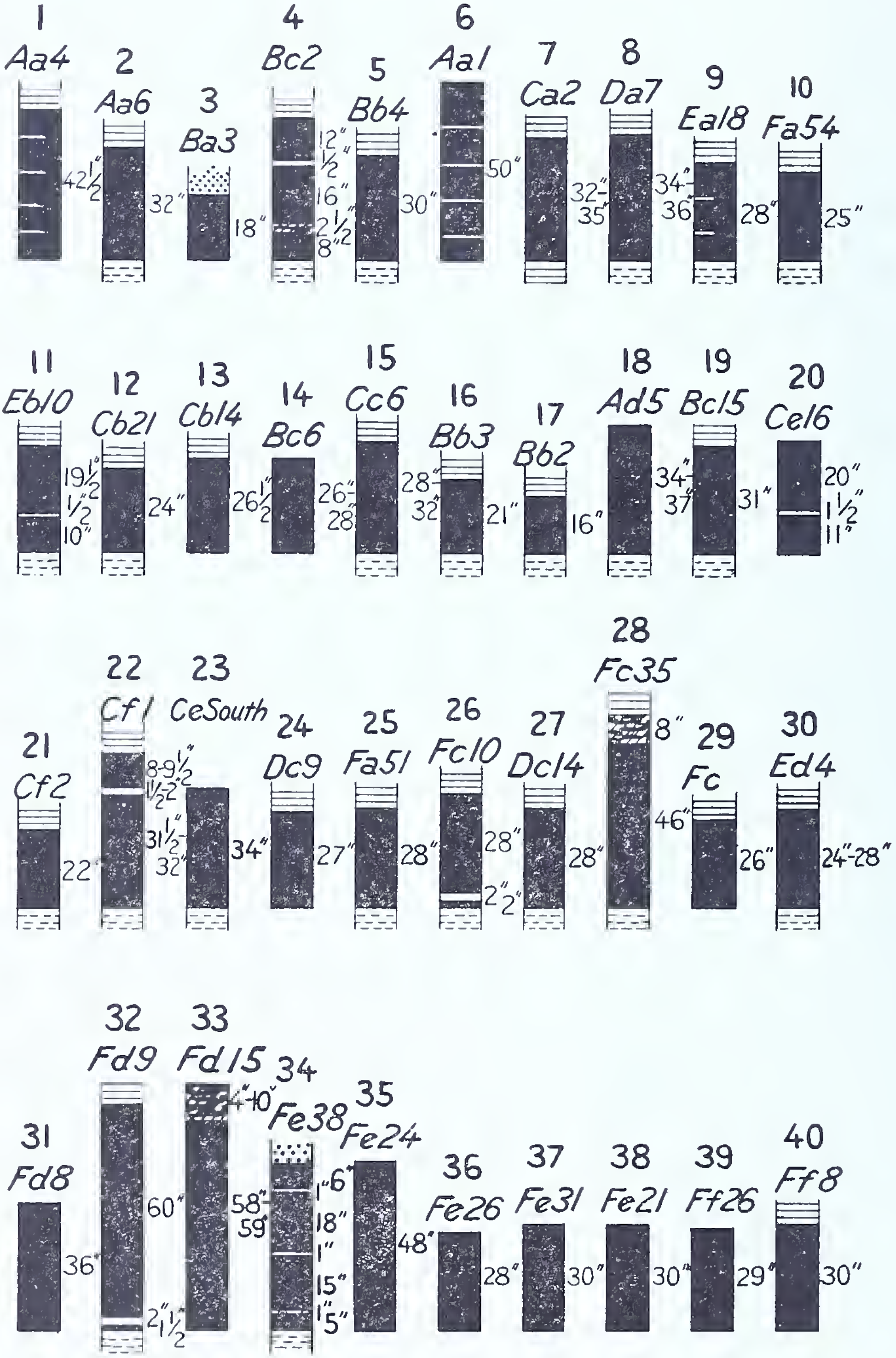


Figure 16. Sections of Upper Freeport coal.

1	Aa4	Mitchell bank, 2 miles north of Rowles.
2	Aa6	Mitchell bank, head of Beech Run.
3	Ba3	Head of Bell Run.
4	Bc2	On Haslett Run.
5	Bb4	North of Curry Run.
6	Aa1	Groube bank, head of Fryor Run.
7	Ca2	Thomas bank, northwest of Grampian.
8	Da7	Priscilla No. 2 Mine.
9	Ea18	Caldwell Mine.
10	Fa54	1½ miles southeast of Curwensville.
11	Eb10	Head of Porter Run.
12	Cb21	Northeast of Bells Landing.
13	Cb14	1 mile southwest of Hepburnia.
14	Bc6	South of Curry Run.
15	Cc6	2 miles south of Curry Run.
16	Bb3	J. A. Johnson bank, 2½ miles north of Curry Run.
17	Bb2	J. A. Johnson bank, 2½ miles north of Curry Run.
18	Ad5	One-fourth mile northeast of Ostend.
19	Bc15	2 miles northeast of Mahaffey.
20	Ce16	Hutton prospects, 2½ miles southeast of St. Lu.
21	Cf2	McGarvey bank, 1 mile southwest of McPherron.
22	Cf1	Ed Westover bank.
23	Ce (S)	Tobe Westover (Thomas) bank (South of Ce).
24	Dc9	Road exposure, 2 miles southeast of Bells Landing.
25	Fa51	Above Pyramid Mine southeast of Curwensville.
26	Fe10	Samuel Snyder, Jr. bank.
27	Dc14	2 miles west of Kerrmoor.
28	Fc35	1 mile south of New Millport.
29	Fc	In drill section south of Olanta.
30	Ed4	T. P. Wharton bank, 2 miles north of Ansonville.
31	Fd8	Patterson bank, 1½ miles east of Ansonville.
32	Fd9	Sam Lamborn bank.
33	Fd15	M. Bloom bank, 1½ miles southeast of Ansonville.
34	Fe38	McCartney No. 3 Mine.
35	Fe24	1 mile northwest of Glen Hope.
36	Fe26	Irvona No. 9 Mine (above).
37	Fe31	1¼ miles northwest of Glen Hope.
38	Fe21	1½ miles north of west of Glen Hope.
39	Fe26	1 mile north of Glen Hope.
40	Ff8	1¾ miles west of south of Glen Hope.

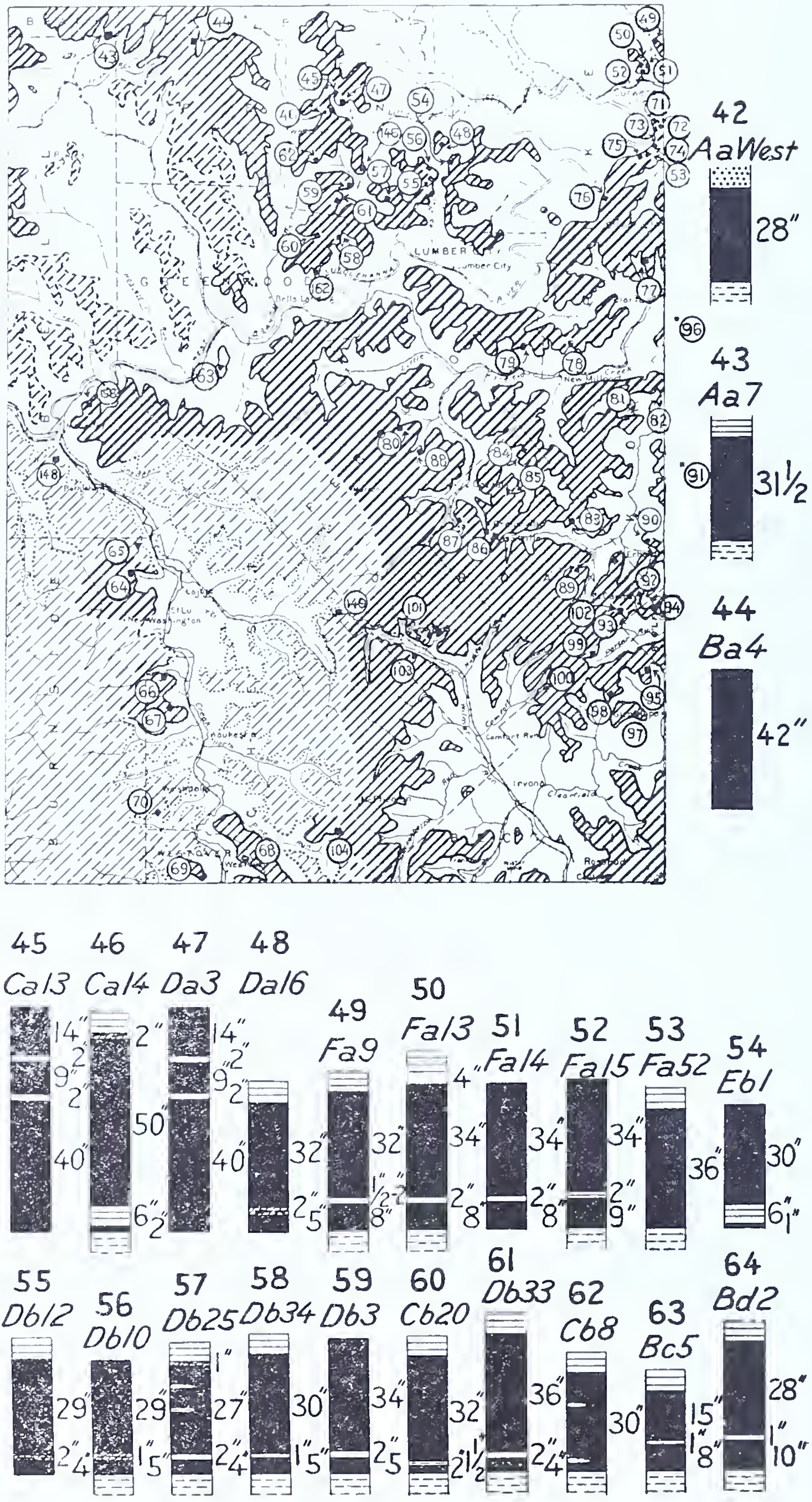


Figure 17. Sketch map showing distribution and thickness of Lower Free-

42	Aa (W)	Mitchell bank (west of Aa).
43	Aa7	Head of Beech Run.
44	Ba4	2½ miles northwest of Walltown.
45	Ca13	Belfast Mine.
46	Ca14	Penn No. 3 Mine—Bell Run.
47	Da3	Penn No. 2 Mine.
48	Da16	1¼ miles east of Grampian.
49	Fa9	On Hogback Run.
50	Fa13	Holden bank, 1 mile northeast of Curwensville.
51	Fa14	1 mile northeast of Curwensville.
52	Fa15	1 mile east of Curwensville (Bickford Mine).
53	Fa52	Pyramid Mine southeast of Curwensville.
54	Eb1	1¾ miles east of Grampian.
55	Db12	Harbison-Walker Mine, 1½ miles southeast of Grampian.
56	Db10	1½ miles southeast of Grampian.
57	Db25	½ mile east of Hepburnia.
58	Db34	1 mile southwest of Hepburnia.
59	Db3	Spencer bank.
60	Cb20	1¼ miles southwest of Hepburnia.
61	Db33	½ mile southwest of Hepburnia.
62	Cb8	¾ mile southeast of Walltown.
63	Bc5	1 mile south of Curry Run.
64	Bd2	Lee Run No. 2 Mine.

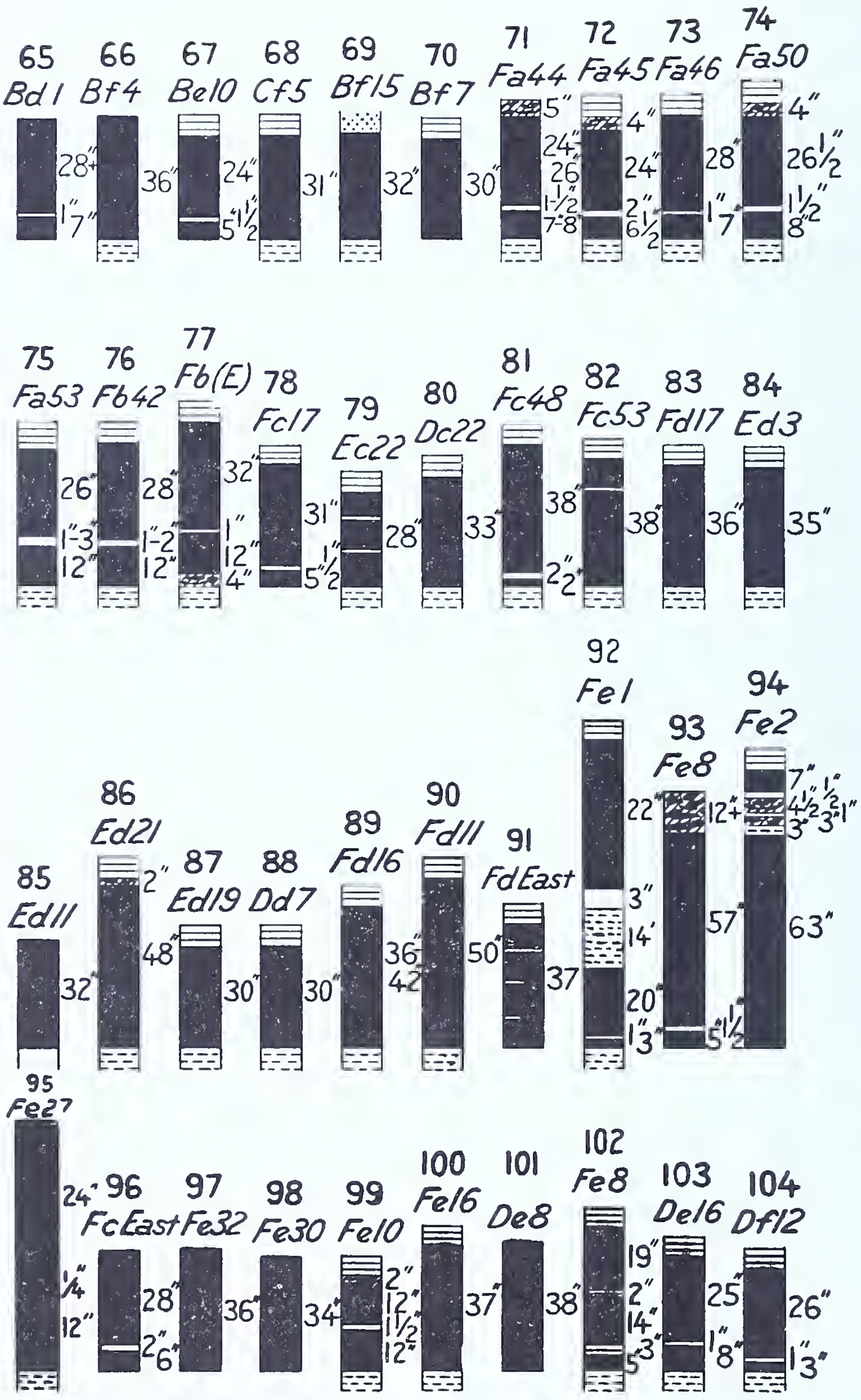


Figure 18. Additional sections of Lower Freeport or D coal.

65	Bd1	1 mile northwest of La Jose.
66	Bf4	South of Waukesha.
67	Be10	Northwest of Waukesha.
68	Cf5	Northeast of Welshdale.
69	Bf15	West of Westover.
70	Bf7	Kings Run southwest of Welshdale.
71	Fa44	Thomson and Leighbough bank.
72	Fa45	Good Mine.
73	Fa46	1½ miles southeast of Curwensville.
74	Fa50	1½ miles southeast of Curwensville.
75	Fa53	1½ miles southeast of Curwensville.
76	Fb42	Caldwell No. 1 Mine.
77	Fb (E)	1 mile east of Bloomington (east of Fb).
78	Fc17	Weis bank, ½ mile north of New Millport.
79	Ec22	Wiley bank, northwest of New Millport.
80	Dc22	W. J. Young bank on Campbells Run.
81	Fc48	R. Caldwell bank, 1¼ miles southeast of New Millport.
82	Fc53	1½ miles southeast of New Millport.
83	Fd17	Carnwath No. 2 Mine, southwest of Kerrmoor.
84	Ed3	2 miles north of Ansonville.
85	Ed11	T. Strong or McNeil Mine, 1 mile east of Gazzam.
86	Ed21	Gazzam No. 1 Mine.
87	Ed19	Gazzam No. 5.
88	Dd7	Gazzam No. 4 Mine.
89	Fd16	Carnwath No. 1 Mine.
90	Fd11	Midvale No. 3 Mine.
91	Fd (E)	East of Fd.
92	Fe1	McCartney Nos. 1 and 2 Mines.
93	Fe8	Penn No. 24 Mine, southwest of McCartney.
94	Fe2	Porter Run No. 1 Mine, southeast of McCartney.
95	Fe27	¾ mile north of Glen Hope.
96	Fc (E)	Grant Kephart bank.
97	Fe32	½ mile west of Glen Hope.
98	Fe30	1¼ mile northwest of Glen Hope.
99	Fe10	Buck Run Mine.
100	Fe16	Head of Porter Run.
101	De8	Cheston bank, at Berwindale.
102	Fe8	Witherow No. 2 Mine near McCartney.
103	De16	Berwindale Mine, ¼ mile south of Berwindale.
104	Df12	McGarvey bank, 1 mile southwest of McPherron.

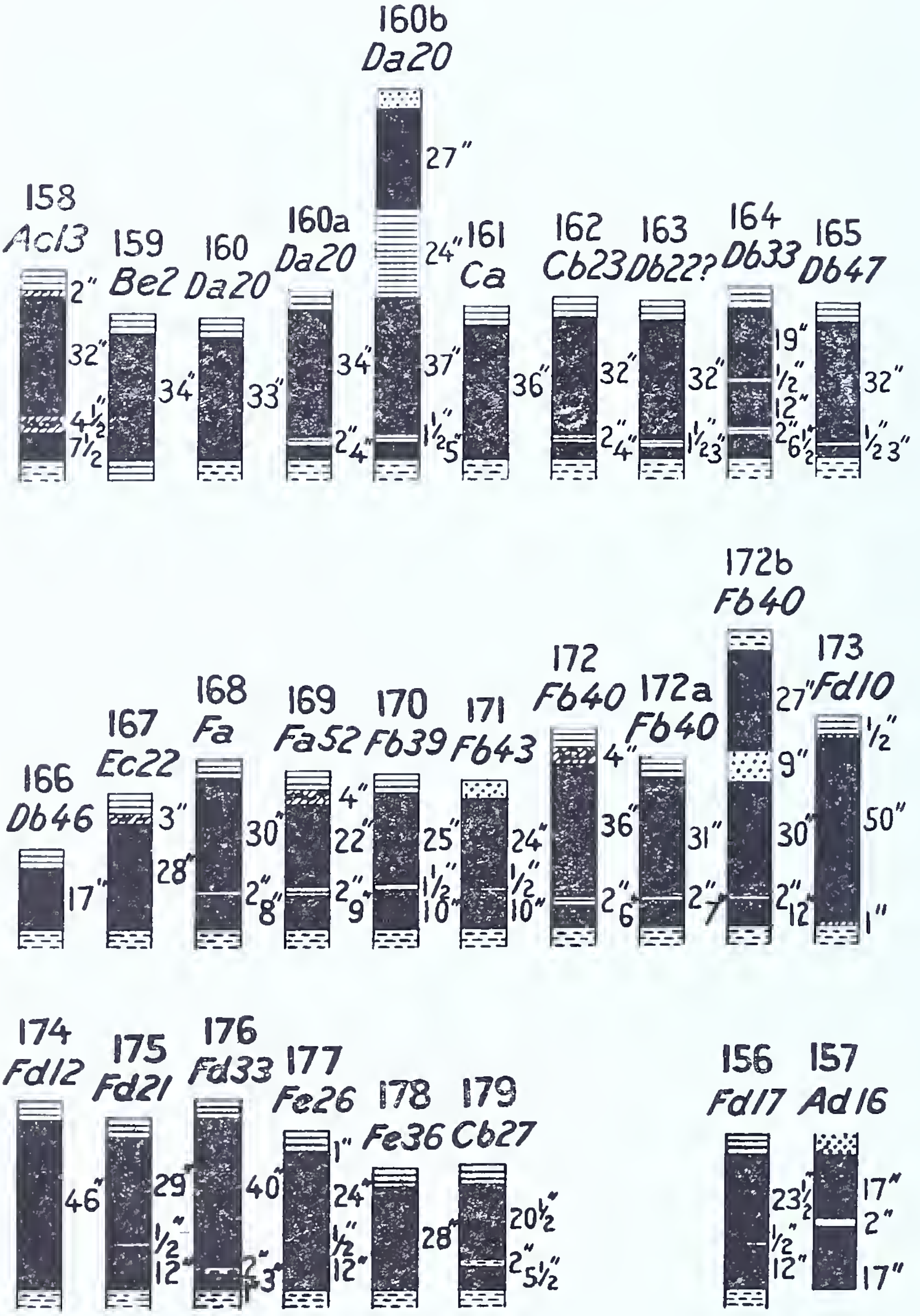


Figure 19. Additional sections of Lower Freeport or D coal.

158	Ac13	M. & N. Mine, east of Mahaffey.
159	Be2	Roberta No. 1 Mine. (See Hollow No. 1.)
160	Da20	Penn No. 4 Mine, near Grampian.
160a	Da20	Same, to show parting. (No. 1 left entry off No. 2 at face.)
160b	Da20	Same, to show variations. (No. 1 right entry at face.)
161	Ca	H. K. Colliery No. 2 near Grampian. Penn No. 5.
162	Cb23	Good No. 22A Coal and Clay Mine, near Bells Landing.
163	Db22?	Coaldale No. 15 Mine, northwest of Lumber City.
164	Db33	Mine southwest of Hepburnia.
165	Db47	Bowers Mine, southeast of Hepburnia.
166	Db46	Curwensville Coal Co., northwest of Hepburnia.
167	Ec22	Good No. 23A Mine, northwest of New Millport.
168	Fa	Bloom bank, 1½ miles northeast of Curwensville.
169	Fa52	Pyramid Mine, southeast of Curwensville.
170	Fb39	Bloomington 19A and 20A Mines, 2½ miles S. of Curwensville.
171	Fb43	Alden No. 2 Mine, west of Bloomington.
172	Fb40	Rowles Station No. 1 Mine, south of Curwensville.
172a	Fb40	Same, another section.
172b	Fb40	Same, section to show variation.
173	Fd10	Central Moshannon Mine, northwest of McCartney.
174	Fd12	Midvale No. 4 Mine, at Erhard.
175	Fd21	Carnwath No. 4 Mine.
176	Fd33	Mine northwest of McCartney.
177	Fe26	Blue Run Mine, north of Glen Hope.
178	Fe36	Glen Hope Mine, west of Glen Hope.
156	Fd17	Carnwath No. 2 Mine.
157	Ad16	Howard Mine, south of Mahaffey.

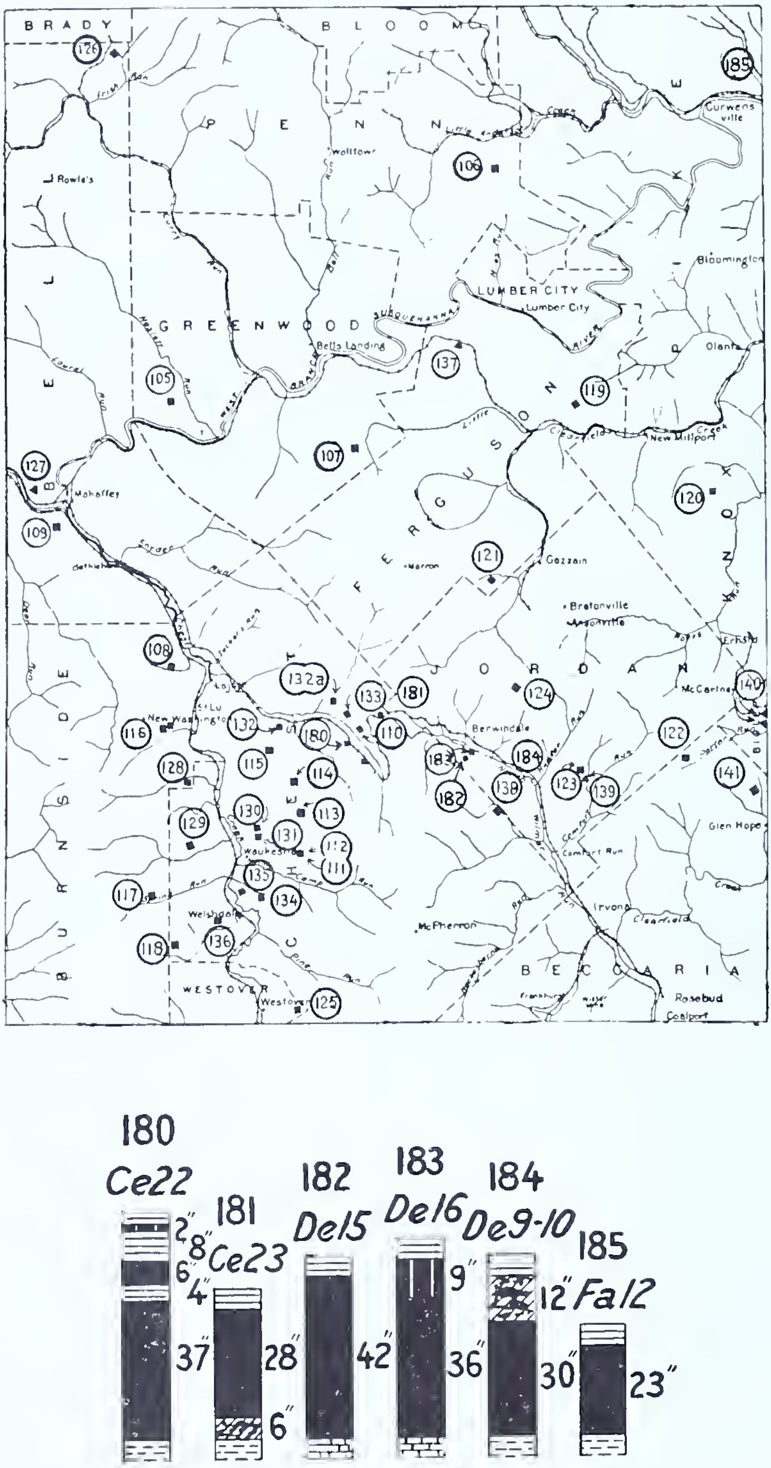


Figure 20. Sketch map of Upper and Middle Kittanning coals and sections on C′ coal.

180	Ce22	Elton Mine, on Wilson Run.
181	Ce23	Bofast Mine, near Mayes.
182	De15	Lakeside Mine, Berwindale.
183	De16	Berwindale No. 1 Mine, Berwindale.
184	De9-10	Small mines, ½ mile east of Berwindale.
185	Fa12	Holden No. 3 Mine, 1½ miles northeast of Curwensville.

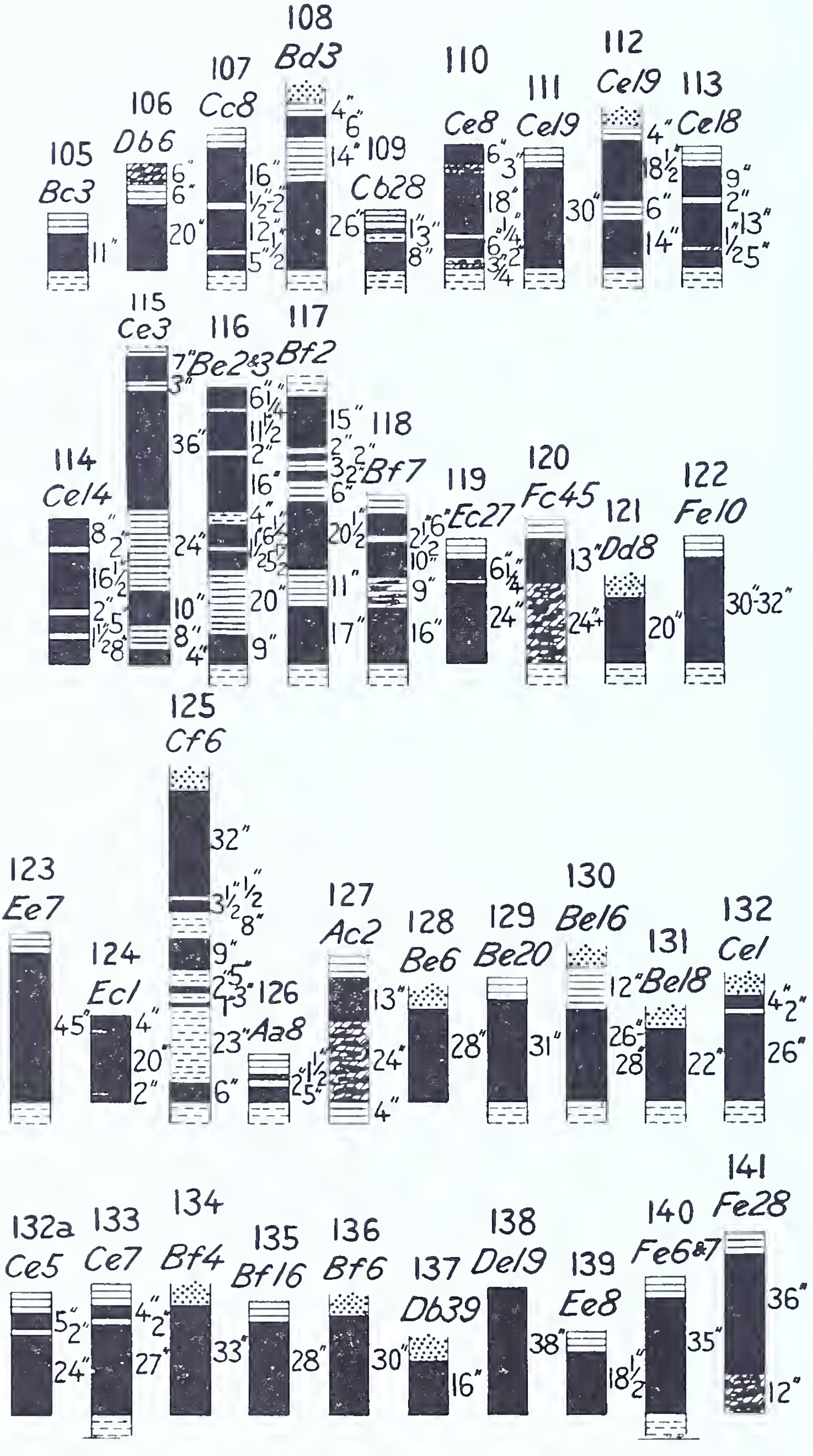


Figure 21. Sections of Upper and Middle Kittanning coals.

C′ COAL

105	Bc3	West of Bell Run.
106	Db6	1 mile southeast of Grampian.
107	Cc8	Watts bank, near head of Little Clearfield.
108	Bd3	Near Lee Hollow Mine.
109	Cb28	Outcrop.
110	Ce8	Wilson Run near Mayes.
111	Ce19	½ mile east of Waukesha.
112	Ce19	½ mile east of Waukesha.
113	Ce18	1 mile northeast of Waukesha.
114	Ce14	Hutton openings.
115	Ce3	Smith bank.
116	Be2-3	St. Lu banks.
117	Bf2	1¾ miles southwest of Waukesha.
118	Bf7	Welshdale No. 4 Mine.
119	Ec27	1 mile northeast of Kerrmoor.
120	Fc45	Southeast of New Millport.
121	Dd8	¾ mile southwest of Gazzam.
122	Fe10	Buck Run Mine.
123	Ee7	2½ miles north of Irvona.
124	Ec1	1 mile south of Lumber City.
125	Cf6	East end of Westover.
132	Ce1	Wilson Run Mine.
132a	Ce5	On Wilson Run.
133	Ce7	Ames No. 1 Mine.

C COAL

126	Aa8	Mitchell bank, on Irish Run (clay mine).
127	Ac2	Northwest of Mahaffey.
128	Be6	1 mile southeast of New Washington.
129	Be20	1½ miles north of Waukesha.
130	Be16	Continental No. 1 Mine.
131	Be18	At Waukesha.
134	Bf4	½ mile northeast of Welshdale.
135	Bf16	½ mile north of Welshdale.
136	Bf6	West of Welshdale.
137	Db39	Outcrop on railroad.
138	De19	1¼ miles northwest of Comfort Run.
139	Ee8	On Comfort Run.
140	Fe6-7	¾ mile southeast of McCartney.
141	Fe28	½ mile north of Glen Hope.

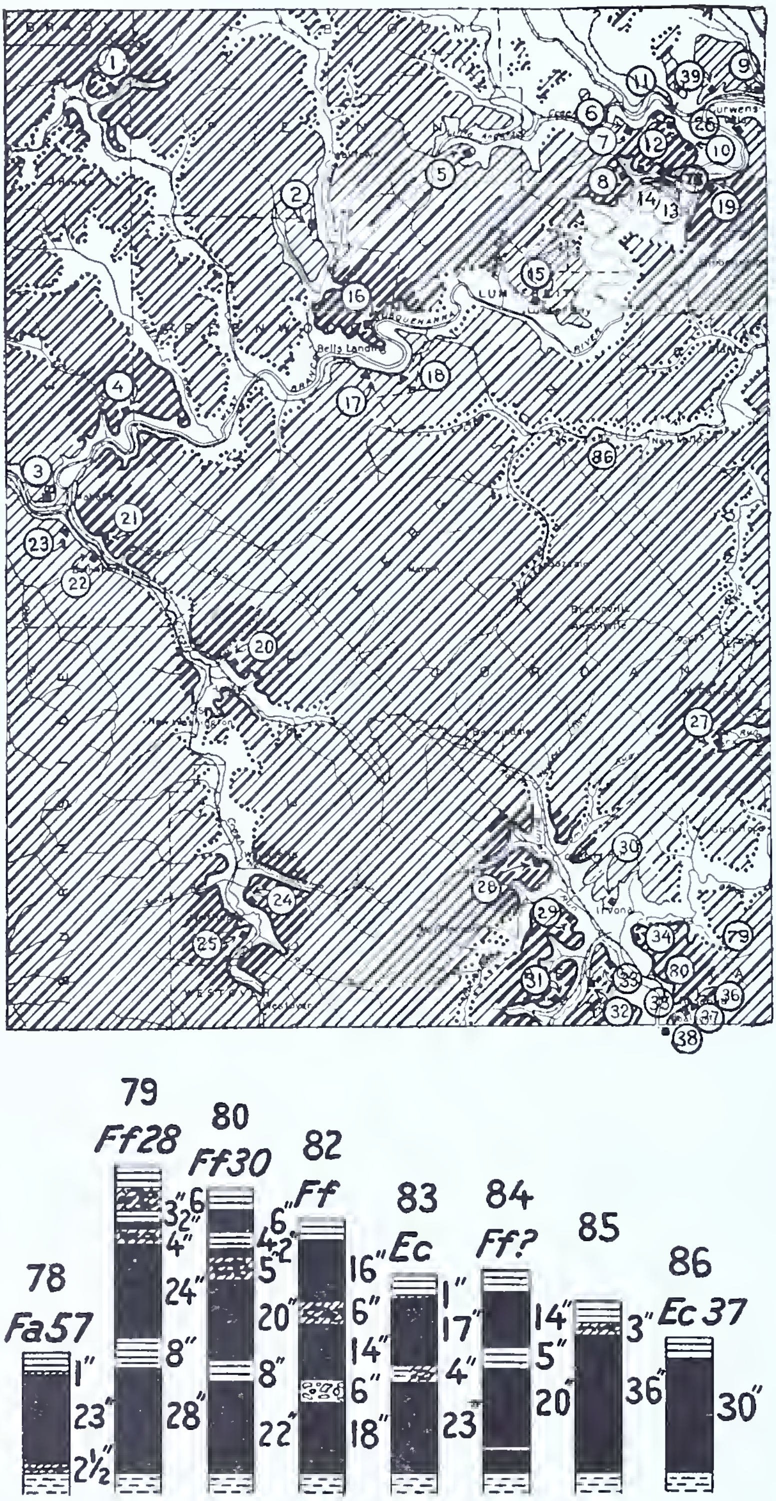


Figure 22. Sketch map showing distribution and probable thickness of Lower Kittanning coal and sections 78 to 86.

78	Fa57	Norris & Co. Mine, south of Curwensville.
79	Ff28?	Irvona No. 10 Mine, east of Irvona.
80	Ff30	Irvona No. 3 Mine, new opening.
82	Ef?	Paramount Mine, ¼ mile west of Coalport.
83	Ef18	Wister No. 3 Mine, on South Witmer Run.
84	Ff?	Cambria Smokeless Mine.
85	Ec	Wallace No. 2 Mine, 5 miles south of Curwensville.
86	37	Sunshine Mine, near New Millport.

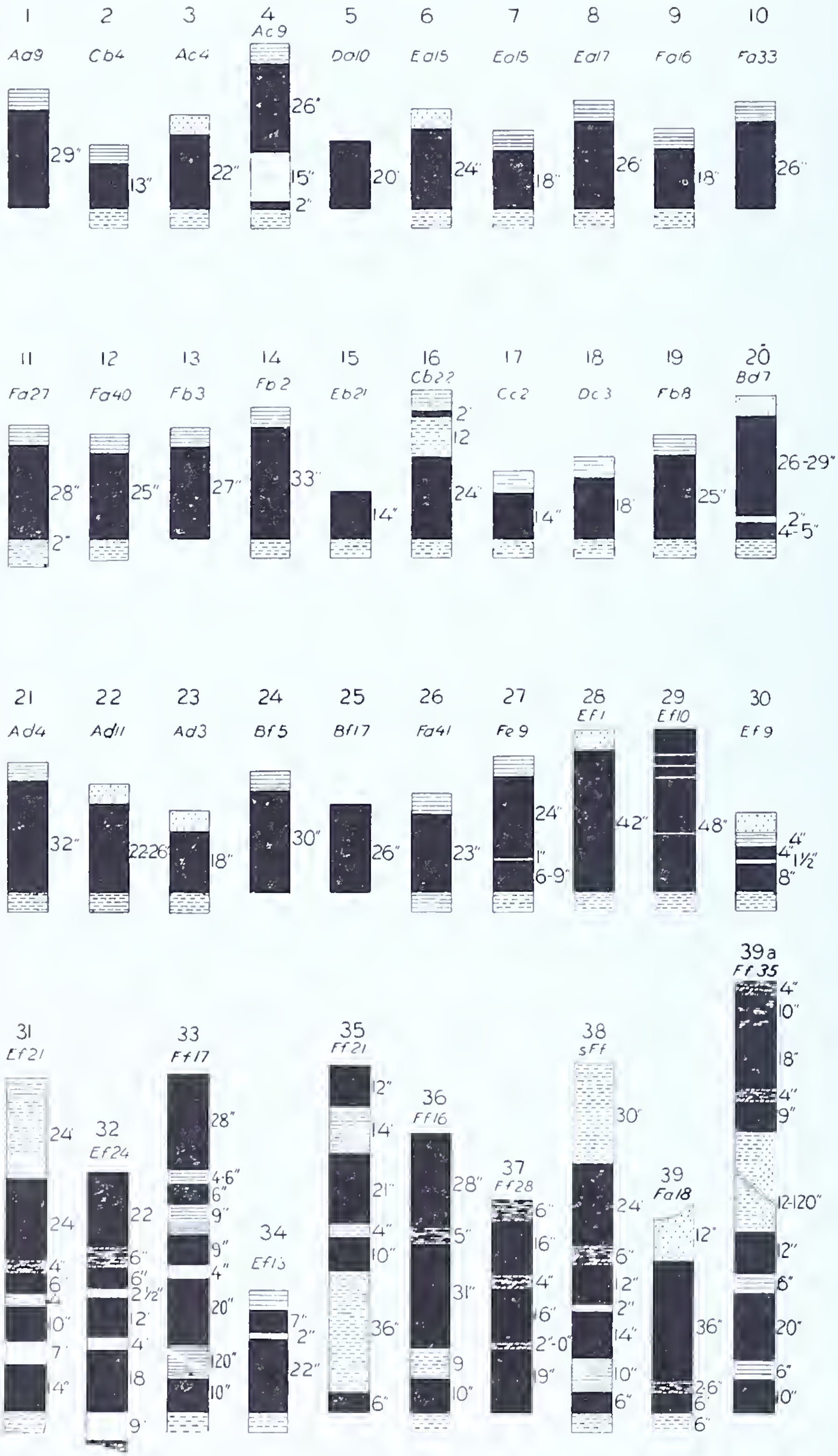


Figure 23. Sections of Lower Kittanning coal.

1	Aa9	2 miles north of Rowles.
2	Cb4	1 mile south of Walltown.
3	Ac4	At Mahaffey.
4	Ac9	2 miles northeast of Mahaffey.
5	Da10	½ mile east of Grampian.
6	Ea15	North American Refractory Company.
7	Ea15	Bickford Mine west of Curwensville (clay mine).
8	Ea17	1½ miles southeast of Curwensville.
9	Fa16	1 mile east of Curwensville.
10	Fa33	Bowers Mine, near Curwensville.
11	Fa27	In Curwensville.
12	Fa40	1 mile southwest of Curwensville.
13	Fb3	1½ miles south of Curwensville.
14	Fb2	1½ miles south of Curwensville.
15	Eb21	At Lumber City.
16	Cb22	1½ miles east of Bells Landing.
17	Cc2	Railroad cut near Bells Landing.
18	Dc3	Railroad cut east of Bells Landing.
19	Fb8	Railroad cut south of Curwensville.
20	Bd7	At La Jose, Jose Mine.
21	Ad4	At Ostend.
22	Ad11	Southwest of Ostend.
23	Ad3	At Mahaffey.
24	Bf5	At Welshdale.
25	Bf17	At Welshdale.
26	Fa41	Railroad cut at Curwensville.
27	Fe9	On Porter Run.
28	Ef1	Black Elk Mine.
29	Ef10	½ mile west of Irvona.
30	Ef9	At Irvona.
31	Ef21	Pennsylvania No. 25 Mine.
32	Ef24	Witmer No. 3 Mine.
33	Ef17	Hyle bank.
34	Ef13	½ mile southeast of Irvona.
35	Ff21	Spangler Wagon Mine.
36	Ff16	Irvona No. 9 "Large Spangler Mine."
37	Ff28	Blain Run No. 1, at Coalport.
38	Ff (S)	South of Coalport.
39	Fa18	East of Curwensville.
39a	Ff35	Swank No. 2 Mine, south of Irvona.

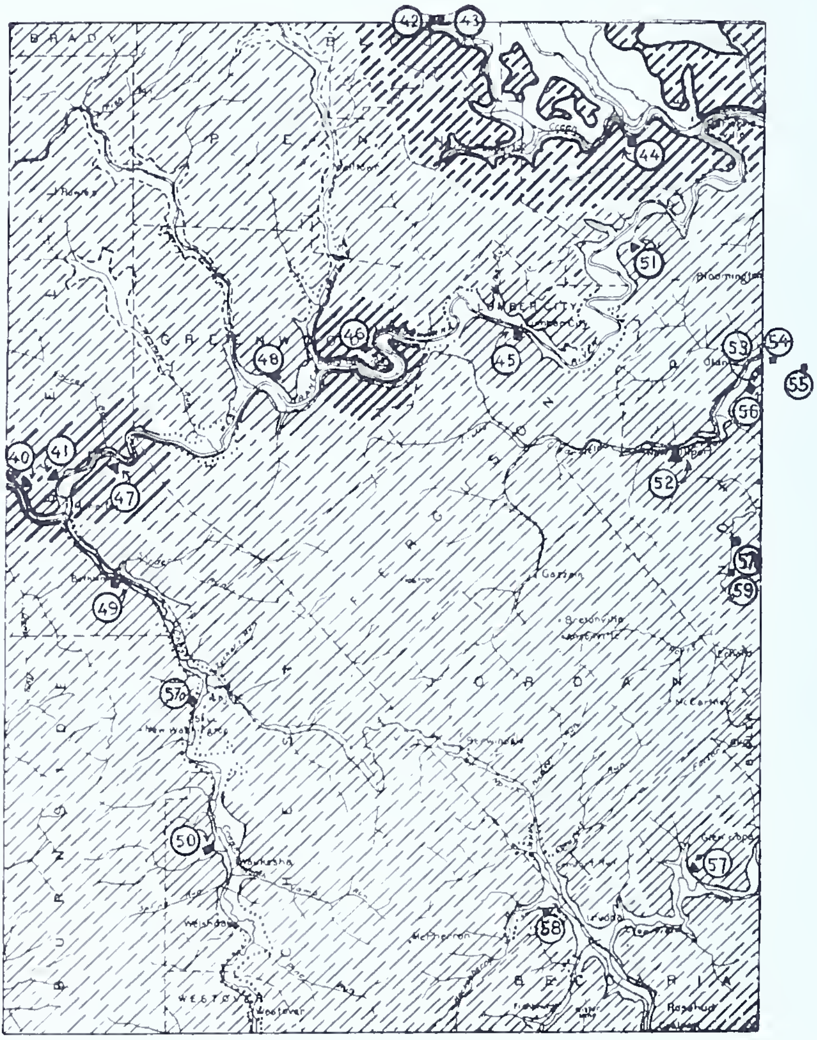


Figure 24. Sketch map showing location of sections, distribution, and thickness of Brookville or A coal.

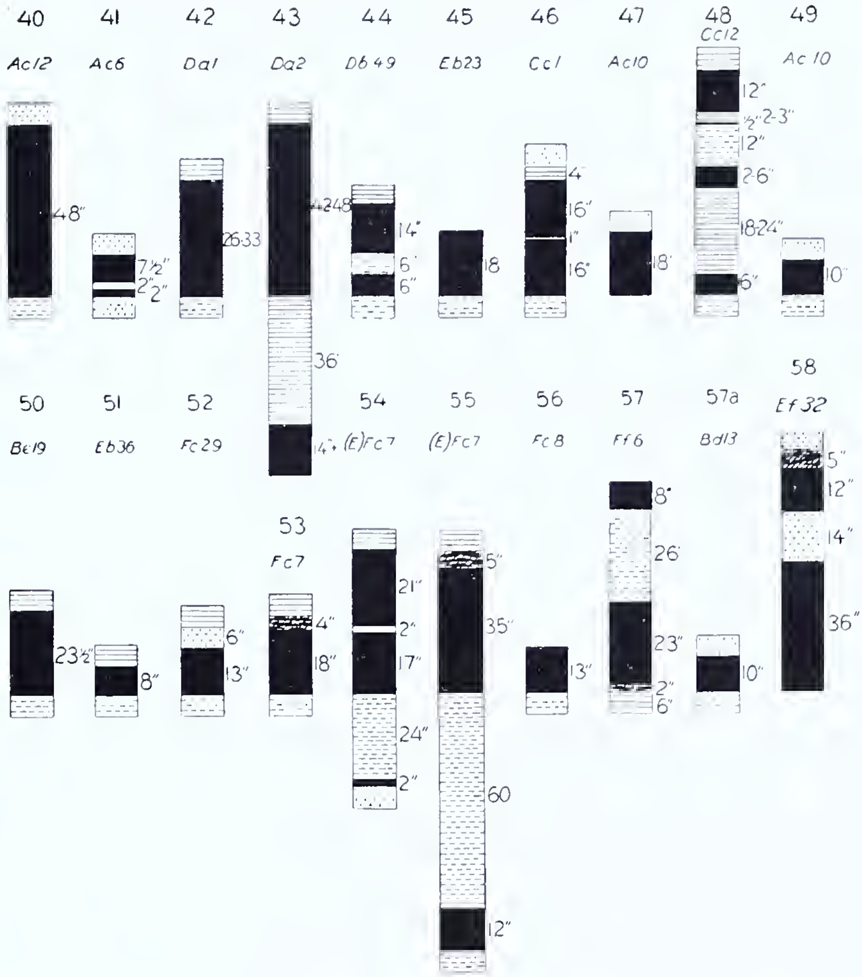


Figure 25. Sections of Brookville or A coal.

40	Ac12	At McGees.
41	Ac6	North of Mahaffey.
42	Da1	On Hughey Run. (A' bed.)
43	Da2	2½ miles north of Grampian.
44	Ea15	½ mile southeast of Curwensville. Bowers Mine.
45	Eb23	At Lumber City.
46	Cc1	Bell Run Mine.
47	Ac10	Near Chest Falls.
48	Cc12	At Curry Run.
49	Ac10	½ mile south of Ostend.
50	Be19	West of Waukesha.
51	Eb36	2 miles southwest of Curwensville.
52	Fc29	½ mile east of New Millport.
53	Fc7	¼ mile southeast of Olanta.
54	Fc7	East of Olanta. (East of Fc7.)
55	Fc7	East of Olanta. (East of Fc7.)
56	Fc8	South of Olanta.
57	Ff6	½ mile northwest of Irvona.
57a	Bd13	West of La Jose.
58	Ef32	Glen Brook No. 2 Mine, northwest of Irvona.

Middle Kittanning (C) coal. The C bed, as shown by the sections (126-141), appears to be a thin, solid bed of good quality. It has been opened at several places, especially along Chest Creek. Hardly enough sections were obtained outside of the Chest Creek region to permit of much generalization. A few of the sections show 3 feet of coal that may be workable.

Lower Kittanning (B) coal. The B bed is a thin solid bed in most of the quadrangle. In the southeast corner of the quadrangle it thickens to 5 feet or more, though much broken with partings. North of Coalport, the B bed splits, the two benches becoming 16 feet or more apart. Being 200 feet below the E bed, the B coal occurs low in the hills in practically the whole quadrangle, and is cut out in the lower part of most of the valleys. The normal roof of the coal is a dark shale overlain by sandstone. Where the sandstone comes down upon the coal, the top of the coal is locally irregular. In connection with the faulting at Coalport, the B coal is in places squeezed up to a thickness of 9 feet. In part of the Coalport district, the roof is clay from 0 to 8 feet thick and, as would be imagined, this clay roof is difficult to hold up. Where thin, the B coal is locally, if not characteristically, long-grained, mining out in blocks or sticks the full thickness of the bed. It is anticipated that the thin bed will be valuable principally as mined with its under clay.

Brookville and Clarion (A and A′) coals. At McGees Mills and thereabouts the A coal has a thickness of 4 feet (section 40) to the west, and east of Olanta it is minable. But in general the A and A′ coals in this region appear to be very irregular. In places a single bed from a few inches to 3 feet thick is found and in other places close by it is split into 3 or 4 beds in a space of 20 to 40 feet. The coal will be found workable locally, especially if mined in connection with its under clay, which, around the town of Clearfield, has proved of value and is being extensively mined. Mining on this bed for coal should not be undertaken without very full prospecting.

Mercer coals. The Mercer coals resemble the Brookville in thickness and irregularity, and in appearing in one place as one bed and in other places as three or four beds. Some of this coal will undoubtedly be mined in connection with the high-grade flint clay which locally underlies it. Unfortunately, in many places the flint clay and the coal are separated by a foot to 15 feet of shale or sandstone or both. Where these intermediate strata occur and cannot be used, they will doubtless render the mining of the coal unprofitable. (For sections, see under clay.)

History of coal mining

Clearfield County's first white settler entered this region in 1785 when James Woodside came to Brady Township. In 1797 Daniel Ogden and his son Mathew settled where Clearfield now is and at about the same time Arthur Bell, Sr., settled at the mouth of Bell Run. A little later Paul Clover "squatted" at what is now Curwensville. Joseph McCrockin and John Ferguson settled in Ferguson Township. Thomas McClure settled about 3 miles above Curwensville. Paul Clover opened the first blacksmith shop and James Galloway opened the first store at Curwensville in 1805.

Though not recorded to the writer's knowledge, it is highly probable that these first settlers discovered coal in the area and may have mined it in a small way, at least for blacksmithing, before or shortly after 1800. In 1804 a barge load of coal was mined from the bed of the river just above Clearfield by W. Boyd and floated down the Susquehanna to Columbia, where it was sold.

During half or more of the 19th century, the principal occupation of the area was lumbering. It was not until about 1840 that farming received much attention. The first railroad entered the county at Osceola Mills in 1862 and 2 years later was extended to Houtzdale and beyond and up Moshannon Creek. Previous to that the only means of getting coal to market was by boat down the West Branch. The report of the First Geological Survey of Pennsylvania in 1858 records that 100,000 bushels of coal had been mined on the Reed place 2 miles below Curwensville and shipped by boat to Harrisburg. Other places in that vicinity also supplied some coal for shipment. Aside from these shipments, commercial coal mining began in the county with the building of the Tyrone & Clearfield Railroad to Osceola and Houtzdale. Later, the railroad was extended to Curwensville, primarily as an outlet for lumber and other products. In 1874 coal was being mined at several places near Curwensville, including the Reed place near the river bridge and mines owned by Dr. Hoyt, Patton, Hoover and others, both above and below Curwensville. About 1883 the railroad at Curwensville was extended to Grampian (formerly Grampian Hills or Pennville, as the region was settled mainly by Quakers). Mines were opened near Grampian. About the same time a narrow-gage railroad to Irvona was changed to broad-gage and mining started there. Still later, the Bells Gap Railroad was extended to Mahaffey, Punxsutawney, and beyond; and the New York Central Railroad extended its Beech Creek Branch to Mahaffey, and up Chest Creek to Patton and up the West Branch. In 1904 the same road built a low-grade line from Bell Run down the Susquehanna, connecting with the B. R. and P. at Curwensville.

In 1903 when the field work for this report was done, the following mines were operating: Near Grampian, the Belfast mine of Atherton and Barnes, the Penn Nos. 2 and 3 of Burns, Bigler and Wright operating as the Clearfield and Grampian Coal Company, the Priscilla Nos. 2 and 3 of the Priscilla Coal Mining Company. Near La Jose the Lee Hollow Nos. 1, 2 and 3, originally Clearfield No. 1, was being operated by the Clearfield-Cambria Coal & Coke Company. On Wilson Run, the Wilson Run mine of Jose & Mosher. At Ansonville, Gazzam Nos. 1-5 of the Clearfield Bituminous Coal Corporation. At Berwindale, the Berwindale No. 1 or Andrew Kennedy mine, and Cheston mine of Grismer and Company. At McCartney, the Porter Run mine by Hilling Morgan and Company, Falcon Nos. 1 and 3 by Quinn and Simler. At Erhard, Midvale Nos. 1 and 2 of W. A. Gould and Brother. At or near Coalport, the six mines listed above and in addition, Irvona Nos. 3 and 4 of the Irvona Coal and Coke Company; Blain Run Nos. 1, 2 and 10 of the Blain Run Coal Company; Oakland No. 2 of S. Hegarty's Sons; Superior mine of the Coalport Coal Company. Oakland No. 4 of S. V. Davis and Company, Witmer Nos. 2 and 3 mine of the Witmer Coal & Coke Company. At that time the Welshdale mines Nos. 1-4 and others had been opened and abandoned. The above list does not include many small mines or "country banks" delivering coal only by wagon, some of which did a very considerable business in the course of a year, but as a rule employed below the minimum number of men to bring them within the scope of the State mining law.

According to the State Mine Inspector's Report for 1889, the first report available, there were six commercial mines around Coalport. These were the Irvona Nos. 1 and 2 and National Nos. 1 and 2 of the Philadelphia Coal & Coke Company, Oakland No. 2 owned by Sam Hegarty, Great Bend No. 3 of the Great Bend Coal Company.

In 1891 the Irvona mines were being operated by the Irvona Coal & Coke Company and the National Nos. 1 and 2 mines on Witmer Run by the Witmer Coal & Coke Company. During the 10 years from 1890 to 1900 mining continued and new mines were opened in the districts already noted, and mining began at Grampian, Gazzam, La Jose, Wilson Run, Berwindale and elsewhere. Between 1900 and 1903, at which time the field work for this atlas was done, mining continued in the districts named, with gradual extensions around Coalport and Grampian, and with the opening of new mines in those areas and at Berwindale. The mines on the list of mines not listed above were opened since 1903.

CLAY AND SHALE

Clay

The clay resources consist of the underclay found under the coal beds and suitable for making tile and brick, and flint clay used for making fire brick and refractory wares in general.

Underclay

The underclays, formerly called fire clay, are those that normally occur under the coal beds. Although it is probably true here, as has been found in other areas, that the underclays are more refractory than other clay and shale, and that they can be used to some extent in the manufacture of fire brick, yet in the trade "fire clay" has been more and more restricted to flint clay and certain beds of refractory underclay. The underclays are used either by themselves or mixed with other clay or shale. Throughout central Clearfield County, underclays are used extensively in the manufacture of building brick, tile and other clay products. They are much used for mixing with shale, to secure certain desired qualities for brick, tile, or other ware. They must be used with flint clay in the manufacture of refractory wares as the flint clay is non-plastic and will not bond by itself.

The following analyses of plastic underclay, although not including any samples obtained in this quadrangle, are of closely similar clays and will give some idea of the probable composition of the underclay of this area. They are from Pennsylvania Second Geological Survey Reports M and MM.

Analyses of plastic underclays from the Coal Measures of Pennsylvania.

	1	2	3	4
Silica	59.8	61.9	68.4	58.1
Alumina	24.5	22.9	18.4	26.5
Protoxide of iron	1.6	1.8	1.5	3.2
Titanic acid	1.1	1.9	2.1	...
Lime	.2	.4	.2	
Magnesia	.8	.5	.5	.5
Alkalies	3.1	1.7	2.7	2.1
Water	7.8	8.7	6.3	9.7

1. Freeport, upper clay, from near Bolivar, Indiana County, MM, p. 259.
2. Kittanning, lower clay, from near New Brighton, Beaver County, MM, p. 262.
3. Mercer clay, Indiana County, MM, p. 264.
4. Clay from ¾ mile south of Brookville, MM, p. 84.

The underclays differ chemically from other clays or shales in having a smaller proportion of the oxides of iron, lime, magnesia, soda and potash, commonly called the fluxing elements of the clay because their presence causes the clay to melt at a much lower temperature than would be the case if they were absent. In particular instances, analyses of underclay and shale from the same column of rocks have shown the underclay to carry on an average only about one-half of the percentage of fluxes of the shales. Thus, as compared with the figures given beyond, an average analysis of a clay or shale will show from 10 to 15 percent of fluxes (including iron and lime). On the other hand, as compared with the flint clay, described in the next section, the percentage of fluxes is large, for the latter have almost none, the fact that gives them their high refractory value. This small percentage of fluxes in the underclays is believed to have been due to their association with the plant life from which the coal was formed. Whether the fluxing elements have been dissolved out by downward percolating waters containing humic acid, as some have held, or removed by the plant roots for the use of the plants, has not been determined. Pending a thorough study of the subject, the writer has been inclined to the latter view.

At many of the mines in the quadrangle the underclay has been exposed in cutting ditches for draining the mine water. Generally these ditches were not cut the full thickness of the clay. It has often been possible to supplement the examinations thus made possible by drill records which give the thickness of the clay. The sections given which carry no references to the exact location have been drawn from or supplemented by drill records.

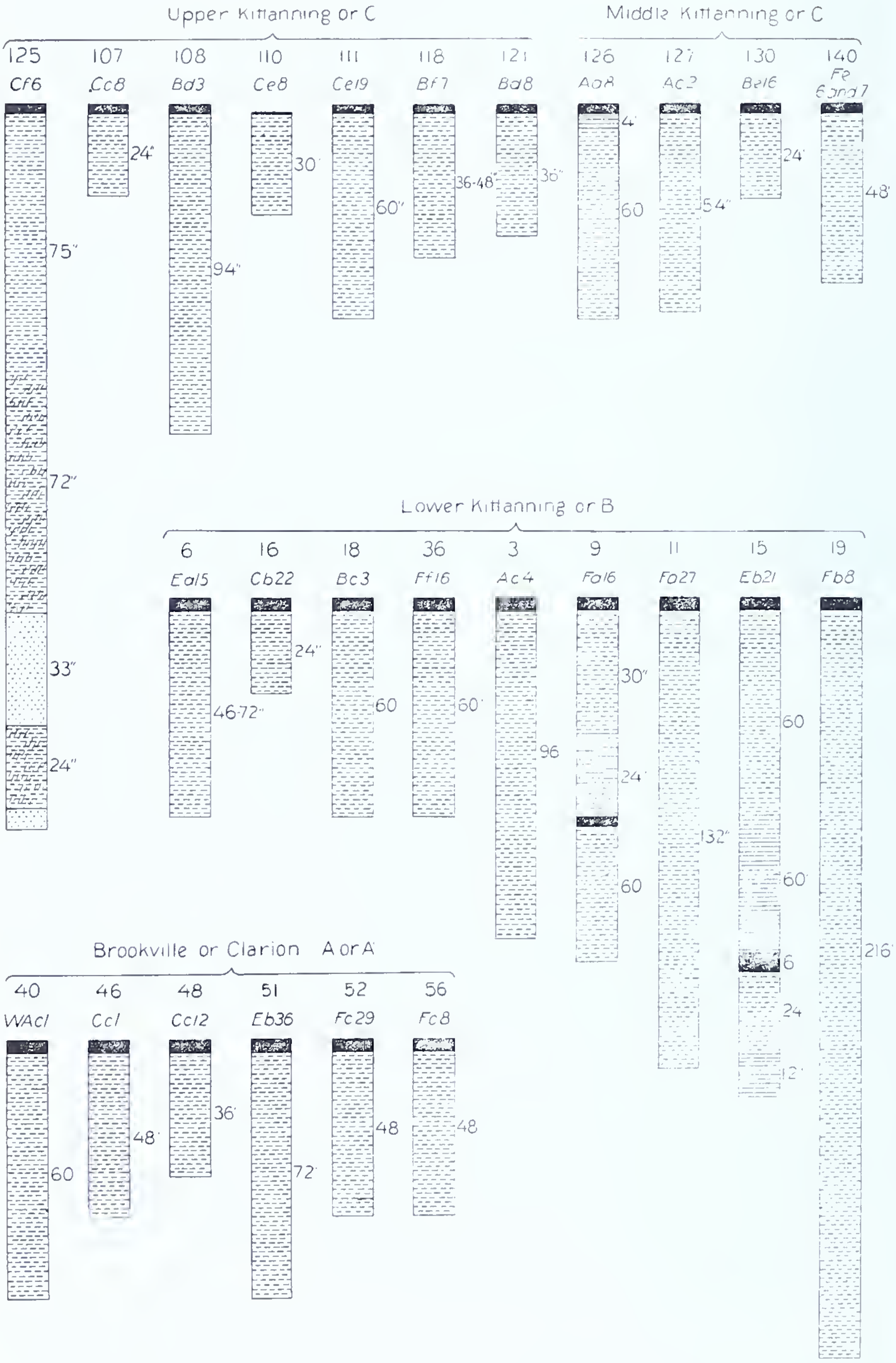


Figure 26. Sections of clays under C′, C, B and A coals.

C′

125	Cf6	east end of Westover.
107	Cc8	near head of Little Clearfield Creek.
108	Bd3	Lee Hollow mine.
110	Ce8	Wilson Run, near Mayes.
111	Ce19	east of Waukesha.
118	Bf7	Welshdale No. 4 mine.
121	Bd8	southwest of Gazzam.

B

6	Ea15	Bickford mine.
16	Cb22	east of Bells Landing.
18	Bc3	railroad cut east of Bells Landing.
36	Ff16	Irvona No. 9 mine.
3	Ac4	at Mahaffey.
9	Fa16	east of Curwensville.
11	Fa27	in Curwensville.
15	Eb21	at Lumber City.
19	Fb8	south of Curwensville.

C

126	Aa8	on Irish Run.
127	Ac2	northwest of Grampian.
130	Be16	Continental Mine.
140	Fe 6 & 7	southeast of McCartney.

A or A′

40		west of Ac1, west of Mahaffey.
46	Cc1	Bell Run Mine.
48	Cc12	at Curry Run.
51	Eb36	southwest of Curwensville.
52	Fc29	east of New Millport.
56	Fe8	south of Olanta.

The distribution of the underclays is the same as that of the coals which they underlie. The lines of outcrop of the Upper Freeport and Lower Kittanning beds, the two principal clays, are shown on the map. The position of the beds associated with the E and D coals can be more readily seen by reference to the sketch maps. Considered in itself, the Lower Kittanning clay is probably the thickest and most valuable clay in this quadrangle as elsewhere in the northern Appalachian region. It ranges from 5 to 8 feet or more in thickness and, judged by its abundant use elsewhere, should be highly suited for the manufacture of light-colored brick and tile, and possibly terra cotta and for use as a bond with flint clay in making high-grade fire brick and other refractory materials. As observed, this clay is a soft, fine-

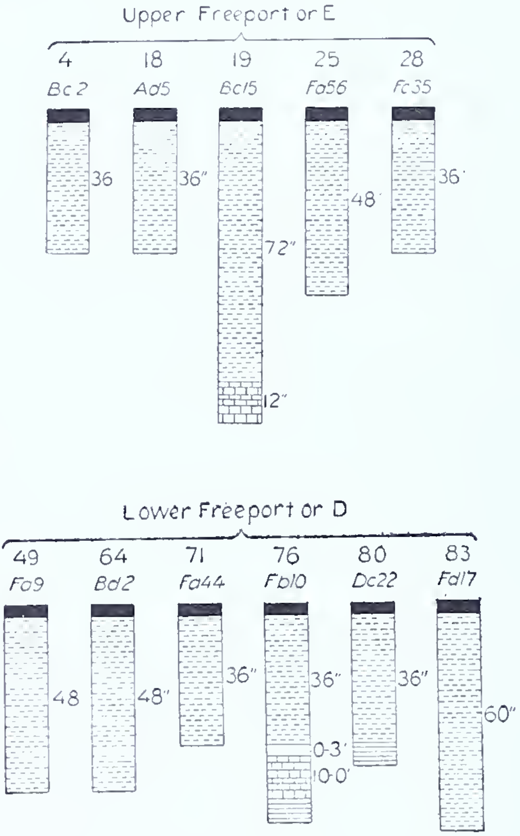


Figure 27. Section of clay under E and D coals.

E

4	Bc2	on Haslett Run.
18	Ad5	one-fourth mile northeast of Ostend.
19	Bc15	2 miles northeast of Mahaffey.
25	Fa56	at Pyramid mine.
28	Fc35	1 mile south of New Millport.

D

49	Fa9	on Hogback Run.
64	Bd2	Lee Run No. 2 mine.
71	Fa44	Thomson & Leighbough mine.
76	Fb10	Caldwell No. 1 mine.
80	Dc22	on Campbells Run.
83	Fd17	Carnwath No. 2 mine.

grained, light-drab clay. It underlies nearly the whole quadrangle and some day doubtless will be won by shaft mining, the coal and clay being mined at the same time.

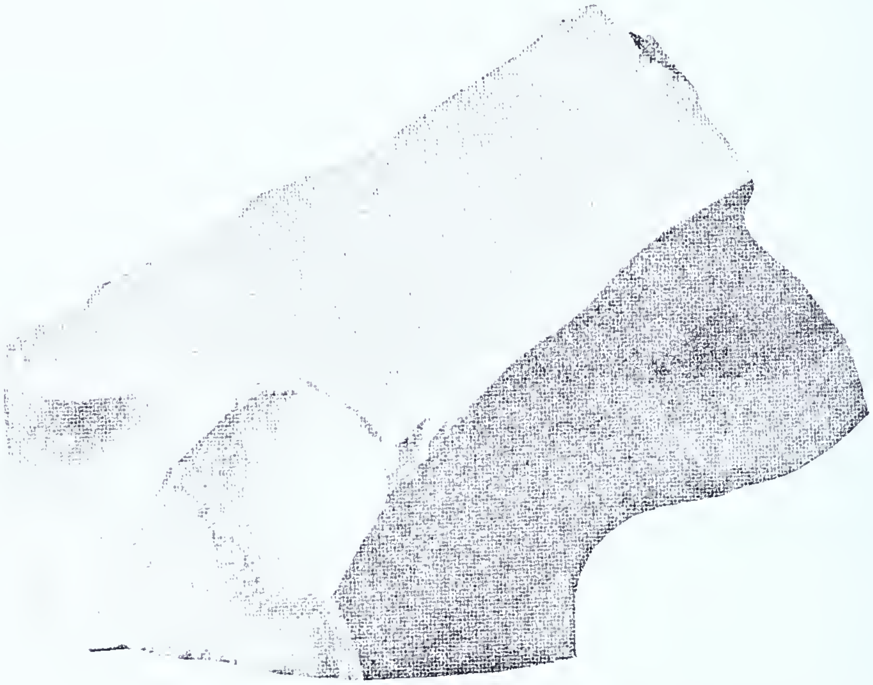
The Upper Freeport underclay is probably second in importance, having a thickness of 3 to 9 feet. As it has not been used commercially in this or adjacent areas, its behavior in use is uncertain. The same may be said of the underclays below the D and C′ coals. The C coal underclay is being used for tile near Clearfield and, in the same region, the A coal underclay is extensively used for brick. It is possible that the clays of this quadrangle may not have the same qualities as the same clays elsewhere, but the fact of their successful use elsewhere in closely adjacent regions makes probable their adaptability to similar usage here. The possible use of these clays in connection with the mining of the thinner coals has been mentioned.

The clay under the B coal is uncommonly thick near Curwensville, as shown by the sections. It appears, as elsewhere, to be the thickest and most promising of the beds. Tests of clay under the D coal at Carnwath and of the B clay at Stronach are given beyond.

Flint clay

Flint clay is the name given to a variety of clay found mainly in association with the underclay in the coal fields. Physically, the variety known as block clay, resembles a limestone strikingly, having a flint-like fracture with sharp, knife-like edges resembling true flint and has frequently been mistaken for a drab limestone (see Figure 28). In color it is light to dark drab. Some of the rock is mottled with dark spots, which burn light in the kiln. In some localities flint clay contains bluish, transparent spots. It is hard enough to ring under the hammer almost like a limestone, and does not weather to a plastic mud as do most clays, but breaks into smaller and smaller fragments or chips which maintain their hardness and flinty character until reduced almost to powder. Two varieties of flint clay are recognized in the trade, the block and nodular or burly. The former breaks with smooth, conchoidal surfaces and sharp, flint-like edges. The other breaks with more irregular surfaces, which are covered with low rounded protuberances and irregularities (the nodules) resembling slightly the surface of a split piece of curly hardwood. So far as observed, no regular difference in quality accompanies the difference in appearance. In some places the block clay is of better grade and in others the nodular.

Flint clay, if ground and molded by itself, will not bond into brick. To be used it must be mixed with a certain proportion of plastic clay. The proportion of soft clay demanded varies with the use to which the refractory ware is to be put. If very high refractoriness is not demanded, a larger percentage of soft clay may be used or, if the brick is subject to wear, it may be necessary to increase the percentage of soft clay to give it the requsite toughness. For this mixing, the clay under the B coal is being used extensively.



A. Block flint clay, from west of Blue Ball, Clearfield County.

B. Nodular flint clay, from west of Curwensville.

Figure 28. Flint fire clay.

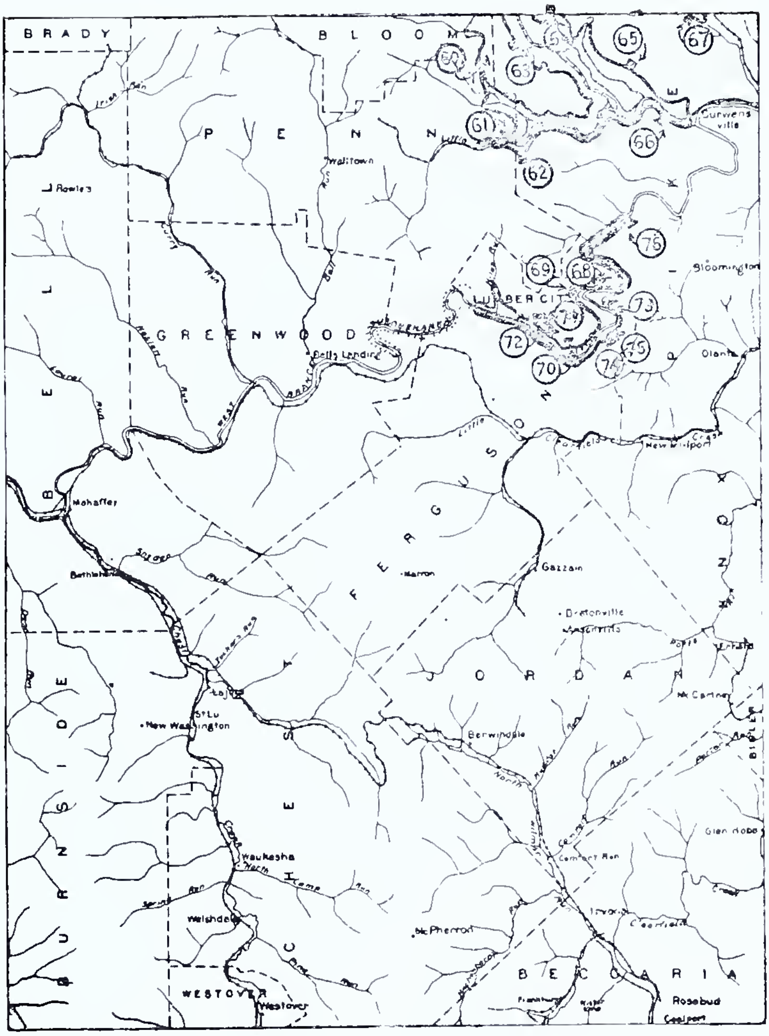


Figure 29. Sketch map showing distribution of Mercer coal and clay.

Flint clay occurs in this region at five horizons: at the Wehrum clay horizon, 30 to 40 feet above the E coal; under the Upper Freeport limestone; and under the C′, B, and Mercer coals. The Wehrum clay may be dismissed as valueless in this region. As far as noted, it has the aspect of a flinty shale. The flint clay under the E coal has been mined successfully at Bolivar, not far southwest of this area, and though not seen in this area, it may prove to be present. The flint clay under the C′ coal crops out in a small area about Westover and has been prospected at several points just east of Westover, one opening (Cf6) showing from 3 to 5 feet of attractive-looking clay. The flint clay under the B coal crops out at several places. No prospect pits were found on it. Experience with this clay farther east in Clearfield County indicates that prospecting may prove it to be pockety, occurring in good body and high-grade close to the outcrop and where the cover is slight but thinning out under deeper cover. This feature has characterized this bed in many areas and led the writer to suggest, as a possible factor in the origin of the flint clay, the action of surface waters percolating downward through the soft clay.

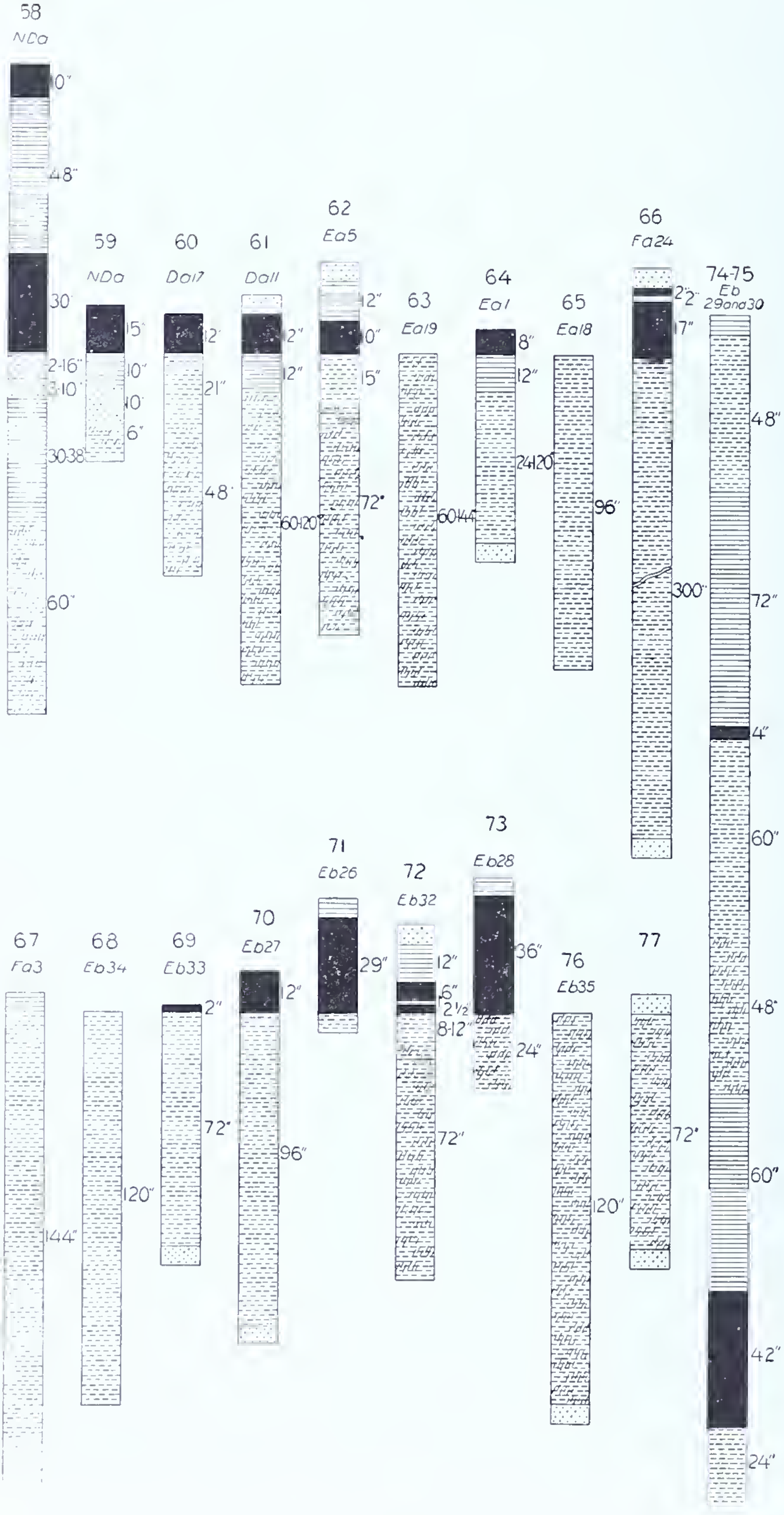


Figure 30. Section of Mercer coal and clay.

58	Da (N)	Korb mine north of Bilgers Run.
59	Da (N)	Korb mine north of Bilgers Run.
60	Da17	on Upper Bilgers Run.
61	Da11	at Stronach.
62	Ea5	Harbison - Walker, Stronach mine.
63	Ea19	on Anderson Creek.
64	Ea1	Ross & Bloom mine.
65	Ea18	Reeper clay mine.
66	Fa24	in Curwensville.
74-75	Eb 29-30	east of Lumher City.
67	Fa3	north of Curwensville.
68	Eb34	northeast of Lumher City.
69	Eb33	northeast of Lumber City.
70	Eb27	southeast of Lumber City.
71	EB26	southeast of Lumber City.
72	Eb32	Good clay mine.
73	Eh28	1½ miles below Lumber City.
76	Eb35	2 miles southwest of Curwensville.

The Mercer flint clay is the principal clay of this kind on the Curwensville quadrangle, as it is farther east. Its location on Anderson Creek and Susquehanna River is indicated by the green line on the Mineral Resource Map. It is mined at Lumber City, Stronach, and places along Anderson Creek. At Lumber City the flint clay is from 2 to 6 feet thick, mostly of the block variety, and underlain by 2 feet of low-grade clay, used as a floor. Over the flint clay is from 8 to 12 inches of low-grade dark shaly clay underlying the Mercer coal, here less than 1 foot thick. At Stronach the flint clay ranges from 5 to 10 feet in thickness and is block and nodular. Over it is 2 feet or less of soft, poorer-grade clay covered with 6 inches to 1 foot of coal. The massive Homewood sandstone forms bluffs above the coal. In places the clay thins away.

The clay has been mined on the west side of Anderson Creek just under the Homewood sandstone that makes the prominent cliff at the top of the bank. In this area it is mined by drifting and stripping. At one stripping it ranged from 5 to 12 feet in thickness, but was irregular in quality as well as thickness. Just north of the quadrangle the same clay has been worked at the Korb mine by stripping and drifting. The clay has a thickness up to 5 feet or more; it may be overlain by coal or separated from it by as much as 5 feet of shale, sandstone and clay. Block clay predominates, but both nodular and mottled clays occur at this place near the roof when present. The upper part of the clay bed is said to be more refractory than the lower part. The coal above is from 15 to 30 inches thick and overlain at a few feet by a thinner bed. On the east side of Anderson Creek the same bed is mined at the north edge of the quadrangle (Ea1) where the clay has a thickness up to 18 feet. It crops out and has been tested at several points in the northeast corner of the Curwensville quadrangle.

The following selected analyses of flint clays will serve to show their composition. It will be noted that they have much less silica and fluxes than ordinary clays, and much more alumina. In fact, they approach very closely in composition to kaolin, or pure clay substance, which contains silica (SiO_2) 46.3 percent; alumina (Al_2O_3) 39.8 percent; water (H_2O) 13.9 percent.

Selected analyses of flint clays

	1.	2.	3.	4.	5.
Silica	43.9	44.0	44.3	44.9	46.2
Alumina	38.1	37.5	38.5	37.7	37.5
Protoxide of iron	.8	.8	1.0	2.7	1.9
Titanic acid	2.6	1.8	1.5	...	...
Lime	.2	.5	tr.	.3	.1
Magnesia	...	.2	.1	.2	.1
Alkalies	.2	.0	.2	.9	1.1
Water	14.2	15.2	14.5	13.0	13.5

1. Bilger clay, one mile from Curwensville, Pa. 2d Geol. Survey, MM, p. 265.
2. Ex-Gov. Bigler's clay, about 1 mile southwest of Clearfield, ibid. MM, p. 265.
3. Mercer clay, Mt. Savage, Md., ibid. MM, p. 266.
4. Mercer clay, Sandy Ridge, Centre Co., Pa., ibid. M, p. 81.
5. Mercer clay, near Woodland, Clearfield County, ibid M, p. 83.

Samples of the Mercer clay were cut at Lumber City, Stronach, and at the Ross and Bloom mine at the north edge of the quadrangle. These were sent to Washington for testing by the U. S. Bureau of Standards. The results of the tests are given in the following report.

The methods of conducting the tests are described as follows by the Bureau of Standards and the tests are given on page 92.

Preparation. Each sample as received was ground dry in a Stevenson pan and passed through a 20 mesh sieve. The ground clay was tempered with water, wedged on a marble slab, and molded into briquettes 2" x 2" x 1" by pressing by hand into a brass mold.

Drying. The briquettes were dried in air for 24 hours and then in an electrical drying oven until constant in weight, the final drying temperature being 110° C. The percent water of plasticity was calculated from the loss in weight in drying. Volume measurements were made in a Seger volumeter upon the briquettes before and after drying and the percent volume drying shrinkage calculated on the basis of the dry volume.

Burning. The dried briquettes were placed in a down draft test kiln in such a manner that two briquettes from each sample could be drawn from the kiln at temperature intervals of 30° C. up to 1300° C., and at 25 temperature intervals from 1300 to 1475° C.

Three draw trial burns were made, two of them terminating at 1300° C. and one terminating at 1475° C.

The volume shrinkage of the burned briquettes as determined in a Seger volumeter and the volume shrinkages calculated as shown in the accompanying table.

The porosities of the burned briquettes were determined in the usual manner by the use of the formula $\frac{W - D}{W - S} \times 100 =$ percent porosity, in which W is the net weight, D the dry weight, and S the suspended weight of the briquettes. The percentage porosities of the briquettes burned to the different temperatures are shown in the table.

Small test cones were molded for each sample and their softening points compared to those of standard pyrometric cones in an electric furnace.

Later (1925), additional samples of clay were collected by George Longcor, an experienced clay sampler. Most of these were taken in the neighborhood of Bells Landing. The samples were studied at the ceramics laboratory at State College under the supervision of Professor J. B. Shaw. The results of the tests and descriptions of the clays follow:

Sample No. 1. Clearfield County, Greenwood Township: a shale owned by Robert L. Derrick, Clearfield Pa. It was obtained on the Derrick estate ½ mile from Bells Landing, underlying the Pennsylvania Coal & Clay Corp. mine No. 2 in the Lower Freeport or D coal. The shale is soft with a conchoidal fracture; it is 4 feet thick, medium gray, slightly oxidized, has a medium iron surface stain, and is a homogeneous mass. The country is hilly. The N. Y. C. R. R. runs within ½ mile of the mine opening; both fuel and labor supply are good. The shale is not developed. The sample is medium hard, contains a medium amount of iron, and has very good plasticity.

The data obtained indicate that this shale has no economic value.

Sample No. 2. Clearfield County, Penn Township: a flint nodular clay owned by the Harbison-Walker Refractories Co., Pittsburgh, Pa. It was obtained 1 mile southeast of Grampian along the Pennsylvania R. R. The bed is in the Allegheny group. Both fuel and labor supply are good. The clay is obtained by mining, handled by mine cars, and manufactured into fire brick and refractory material. The sample shows a splintery fracture, is medium gray, very hard, contains a slight amount of iron, and has poor (sandy) plasticity.

Tests of fire clays in Curwensville Quadrangle

[By the U. S. Bureau of Standards]

Sample No.	Location	Plasticity	Water of plasticity in percent dry weight	Volume drying shrinkage in percent dry weight	Softening point in Seger cones
1	Carnwath Mine No. 2, clay underlying coal	fair	18.8	13.7	25
2	Ross mine, Lumber City	none	13.2	5.4	33
3	Ross-Bloom mine, above Curwensville, Bickford Company	none	13.7	5.5	32
4	Hard clay mine, Stronach, Harbison-Walker Refractories Co.	none	12.7	4.9	32
5	Nodular clay from Stronach	none	13.2	3.5	33
6	Soft clay mine, Stronach	very fair	20.3	14.1	15

[Figures represent porosity and volume burning shrinkage]

Sample No.		1000°	1030°	1060°	1090°	1120°	1150°	1180°	1210°	1240°	1270°
1	a	22.7	21.8	18.4	15.4	13.0	9.6	12.7	17.7	21.8	
	b	5.6	7.8	10.4	13.5	15.3	16.5	8.1	2.2		
2	a	25.4	25.8	24.9	24.4	24.3	23.4	23.1	22.6	22.2	22.0
	b	9.1	10.3	10.6	12.4	13.1	13.2	13.8	13.8	12.2	11.6
3	a		27.1	26.5	26.4	26.5	26.4	26.0	26.0	25.5	24.4
	b		9.0	10.4	11.8	12.5	12.9	12.3	12.4	12.6	12.6
4	a		25.7	25.8	25.0	24.6	23.5	24.1	22.9	23.7	23.5
	b		12.5	13.3	14.0	15.2	15.9	16.1	16.5	16.3	15.9
5	a		33.9	33.8	32.8	34.2	34.1	33.8	32.9	33.1	33.1
	b		2.8	3.3	3.8	3.9	5.4	7.2	7.6	8.2	8.4
6	a	24.9	23.5	20.8	15.7	9.0	6.0	6.9	21.2		
	b	5.4	8.5	12.0	16.1	18.6	20.4	8.0			

Sample No.		1300°	1325°	1350°	1375°	1400°	1425°	1450°	1475°
1	a								
	b								
2	a		21.3	21.9	20.8	21.1	20.4	19.1	19.0
	b								
3	a	24.6	22.1	23.8	23.3	32.4	23.4		25.5
	b	11.3							
4	a	23.8	22.7	23.1	22.6	22.4	22.2	22.2	20.8
	b	15.0							
5	a	32.4	32.7	32.0	32.0	33.7	32.6		33.4
	b	8.6							
6	a								
	b								

(a) Percent porosity.
(b) Percent volume burning shrinkage in terms of dry volume.

DESCRIPTION OF SAMPLES

1. Carnwath Mine No. 2, clay underlying coal. A fairly plastic buff clay which vitrifies at 1150° C. and becomes vesicular at 1190° C. It may be used in the manufacture of porous building brick. Has no value in manufacture of refractories.

2. Ross mine, Lumber City. A refractory flint fire clay which retains a porous structure at temperature up to 1475° C. Mixed with a plastic clay it may be used in the manufacture of fire brick.

3. Ross-Bloom mine, above Curwensville, Bickford Company. A refractory flint clay which retains a porous structure at 1475° C., although its softening point (cone 32) is low for materials of this type. Has value in manufacture of refractories.

4. Hard clay mine, Stronach, Harbison-Walker Refractories Co. A refractory flint clay which retains a porous structure at 1475° C. May be used in the manufacture of refractories.

5. Nodular clay from Stronach. A refractory flint clay which, when mixed with a plastic refractory clay, may be used in the production of fire brick.

6. Soft clay mine, Stronach. A buff burning plastic fire clay which vitrifies at 1150°. It may be used in production of building brick, etc., but has no value in the manufacture of refractories.

The data obtained indicate that this is a high-grade No. 1 fire clay. It has a slow, regular shrinkage beginning at 1050° C. and continuing up to 1400° C.

Sample No. 3. Clearfield County, Greenwood Township: a plastic clay owned by D. F. Bell, Bells Landing, Pa. It was obtained 1 mile due north of Bells Landing along Bell Run. The clay is 10 feet thick, 6 feet being plastic; it is light gray, has a medium amount of iron stain on the surface, and is an earthy, homogeneous mass. The bed underlies the Lower Kittanning coal. The country is hilly. The N. Y. C. R. R. is within 1 mile of the property. Both fuel and labor are available. The clay is not developed. The sample shows an earthy fracture, is light gray, soft, contains a medium amount of iron, and has good plasticity.

The data obtained indicate that this is a fair quality No. 3 fire clay. It overfires at about 1300° C.

Sample No. 4. Clearfield County, Greenwood Township: same owner, place, and bed as No. 3. A flint clay that makes 4 feet of a 10-foot bed. The clay is hard, splintery, and blocky. The sample submitted shows a conchoidal and splintery fracture; is steel gray, very hard, contains some iron, and has poor (sandy) plasticity.

The data obtained indicate that this is a rather poor quality No. 2 flint fire clay. It is high in free silica as compared with the general run of flint fire clays.

Sample No. 5. Clearfield County, Greenwood Township: a red clay owned by the Good Coal & Clay Co., Patton, Pa. It was obtained from the bottom clay under the Lower Freeport coal one mile in the hills back of Bells Landing. The clay is 2 to 4 feet thick; medium gray, has a slight iron and carbon stain, and is a soft homogeneous mass. The country is hilly. The N. Y. C. R. R. is present with coal mine sidetrack. The clay is obtained by mining, handled by mine cars and gravity plane to tipple, and shipped and manufactured into tile at the Patton works of the company. The sample shows a conchoidal fracture, and has very good plasticity.

The data obtained indicate that this is a red burning clay, which would be very difficult to manipulate.

Sample No. 6. Clearfield County, Greenwood Township: a flint clay owned by the Passmore Estate, Bells Landing, Pa. It was obtained from a natural outcrop of clay along the bank of Susquehanna River 1 mile below Bells Landing. The clay is hard and splintery; it is 6 feet thick, medium gray, unoxidized, has no surface stain, and is homogeneous. It is known as the A clay, Brookville horizon, but the Brookville coal is absent. The N. Y. C. R. R. runs through the property. Both fuel and labor supply are good. The plant was not operating in 1925. The sample shows a splintery fracture; is medium gray in color, very hard, and has poor plasticity.

The data obtained indicate that this is a high grade No. 1 fire clay.

Sample No. 7. Clearfield County, Greenwood Township: a flint clay owned by the Hoyt Estate, Bells Landing, Pa. It was obtained in the bed of Susquehanna River, 2 miles below Bells Landing. The clay is hard and splintery; it is 7 feet thick, dark gray, unoxidized, has a medium iron surface stain, and is a homogeneous mass. The bed is near the base of the Allegheny group at the Clarion or Brookville horizon, but the coal is absent. The N. Y. C. R. R. runs through the property. Both fuel and labor supply are good. The clay is not developed. The sample is very hard, and has poor (sandy) plasticity.

The data obtained indicate that this is a high grade No. 1 fire clay.

Sample No. 8. Clearfield County, Greenwood Township: a shale owned by Robert L. Derrick, Clearfield, Pa. It was obtained ½ mile below Bells Landing along Susquehanna River in the Pennsylvania Coal & Clay Corp. mine No. 1. The shale is splintery; 9 feet thick, dark gray, unoxidized, has a slight carbon surface stain, and is a homogeneous mass. It underlies the Lower Kittanning or B coal. The N. Y. C. R. R. runs through the property.

Both fuel and labor supply are good. Coal is mined here but the shale is not utilized. The sample is medium hard, has some carbon, and very good plasticity.

The data obtained indicate that this shale could probably be used for the production of face brick or tile. Its burning properties are satisfactory.

Properties of clays in green state

[Walter Preische and David R. Mitchell, analysts]

No.	Water of plasticity percent of dry weight	Shrinkage water percent of dry weight	Pore water percent of dry weight	Time of slaking minutes	Drying shrinkage percent of dry volume
1	23.27	9.35	13.92	9½	17.60
2	20.38	1.74	18.64	*	2.92
3	22.78	6.54	16.24	10½	11.70
4	21.88	4.85	17.03	2½	7.72
5	23.94	8.72	15.12	4	16.38
6	24.50	7.37	17.13	3	12.30
7	24.14	6.48	17.62	1	10.85
8	21.49	4.90	16.59	7	8.69

* Does not slake.

Fusion

No.	Cone	Deg. C.	No.	Cone	Deg. C.	No.	Cone	Deg. C.	No.	Cone	Deg. C.
1	15	1430	3	20	1530	5	15	1430	7	35	1755
2	32½	1712	4	29	1650	6	35	1755	8	18	1490

Burning shrinkage

[Figures represent volume shrinkage in percent of dry volume]

Sample No.	Degrees Centigrade								
	1000	1050	1100	1150	1200	1250	1300	1350	1400
1	11.81	15.72	17.23	22.86	-----	10.35	—19.45	—63.40	-----
2	-----	5.76	-----	6.06	-----	11.12	11.95	12.55	15.77
3	2.84	-----	9.80	12.28	-----	17.36	22.66	20.40	6.90
4	2.25	-----	2.77	4.52	-----	5.52	5.95	9.47	8.60
5	-----	-----	20.50	30.01	-----	22.38	5.64	—.59	-----
6	-----	16.35	16.75	17.18	-----	-----	22.04	22.26	22.90
7	13.48	16.84	16.27	-----	21.30	-----	22.62	21.84	24.90
8	5.96	-----	6.01	7.61	17.03	17.60	20.87	20.90	21.90

Porosity

[Figures represent percent porosity in terms of burned volume]

Sample No.	Degrees Centigrade								
	1000	1050	1100	1150	1200	1250	1300	1350	1400
1	15.9	----	15.2	9.7	----	7.2	18.3	27.6	----
2	44.1	46.6	45.4	46.1	45.4	43.6	44.4	44.0	43.5
3	31.1	----	30.9	29.5	----	16.8	12.2	5.4	4.3
4	44.3	----	44.5	44.4	----	41.0	41.6	41.8	37.9
5	----	----	15.5	10.8	----	1.8	7.0	10.5	----
6	39.4	37.0	38.1	37.4	----	----	33.8	32.2	34.0
7	35.2	33.5	36.7	33.5	33.3	----	31.4	30.9	28.0
8	35.8	----	34.5	32.5	18.2	18.8	11.8	11.7	2.1

Apparent specific gravity

Sample No.	Degrees Centigrade								
	1000	1050	1100	1150	1200	1250	1300	1350	1400
1	2.39	2.40	2.56	2.55	----	2.12	1.82	1.50	----
2	2.67	2.94	3.02	1.94	2.00	2.96	3.04	3.03	3.15
3	2.55	----	2.73	2.75	----	2.48	2.51	2.26	1.91
4	2.68	----	2.70	2.72	----	2.62	2.66	2.74	2.55
5	----	----	2.63	2.82	----	2.32	2.06	1.96	----
6	2.85	2.73	2.78	2.77	----	----	2.79	2.73	2.83
7	2.61	2.59	2.76	2.51	2.77	----	2.75	2.71	2.70
8	2.80	----	2.74	2.71	2.49	2.52	2.43	2.43	2.18

SHALE

Shale is used extensively in making clay products not requiring refractory properties, such as brick, tile, terra cotta, and especially for those forms requiring, or admitting of, a certain amount of vitrification, such as paving brick. Shale is being used in the manufacture of paving brick at Punxsutawney, and shales similar to those in this quadrangle are utilized extensively in the district about Clearfield, a few miles northeast and east of the Curwensville quadrangle. The shales used are those above the Brush Creek coal, above the C′ coal, between the B and C coals, and near the A coal. Of these shales, that between the B and C coals has been used more than the others. The shales of this region are nearly all very sandy and, as a rule, require mixing with some clay, as one of the underclays, to yield the desired results. The shales most used range from a light drab to a light olive in color, the latter color being more distinctive of the Conemaugh shales, though locally the Allegheny shales also have a decided olive tinge. Most of them appear to be composed of very fine-grained sand with a slight mixture of clay substance, having a smooth feel to the hand but not at all unctuous. In much of this fine-grained shale there is an abundance of manganese markings in the joints, the faces locally being black with manganese. The fracture ranges from fissile on the bedding planes to irregular sub-cubical fractures that break the shale down into small blocks, cubes, or irregular chunks. When somewhat weathered this shale commonly breaks down into little pieces resembling coarse meal or "grits."

SANDSTONE

Most of the sandstones of the area contain a considerable content of clay, are thin-bedded, or irregularly bedded with shale partings. Such sandstone, as a rule, will not yield dimension stone of any size; nor will it resist the influence of the weather. Locally, however, some of the sandstones are fairly pure quartz, chiefly of large grain cemented with quartz, a gray to white or light tan stone that withstands weathering to a marked degree and yields dimension stone of almost any size desired. Such sandstones have been quarried extensively near Curwensville for bridge abutments and other heavy masonry. None were seen that gave promise of sufficient evenness of grain and color for high-grade building stone. Quarrying has developed faces 30 feet or more thick without bedding planes. Such stone is available only where under slight cover, so that the stripping may not become excessive. Figure 11 shows three views of quarries on such sandstone in the Curwensville area.

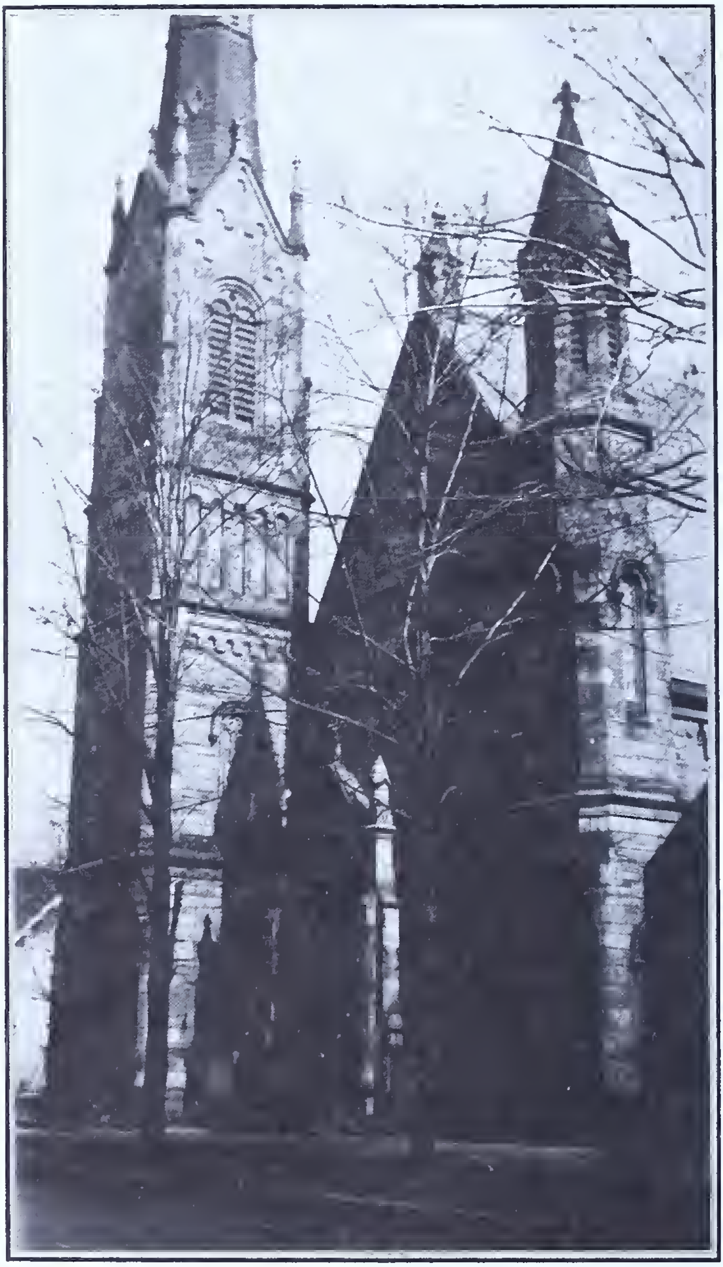


Figure 31. Presbyterian Church, Curwensville, built of local sandstone.

Notes on the stone at some of these quarries will give an idea of the character of the rock in general. Thus, the Homewood sandstone was quarried by the Roaring Run Stone Company, north of Curwensville (Ea2). The quarried stone has a thickness of 38 feet overlain by 6 to 8 feet of soil and weathered sandstone stripping. In parts of the quarry the sandstone is solid for the full thickness. In other parts, a single "crowfoot" or shale parting can be traced a hundred feet or more. Part of the stone is badly broken up with fissures, some vertical and some more or less nearly horizontal. One weathered fissure, full of clay and broken material, shows in the quarry face. The stone is a creamy gray except as discolored by iron, the iron discoloration being too irregular and general to allow the use of the stone for fine buildings. Quarrying is done by the use of the drill, the stone being cut into blocks up to 12 or 15 feet thick at right angles to the bedding.

The same cross-grained saccharoidal sandstone has been quarried by the Conemaugh Company just off the north edge of the quadrangle west of Anderson Creek. In places the stone is almost white, though commonly streaked with iron. Locally the staining is quite uniform. The quarried thickness is between 40 and 50 feet, but the bed is much broken by fracture planes, producing a large quantity of waste. A sandstone in the Clarion member, showing a thickness of 37 feet without bedding, has been quarried a little at Chest Falls (Bc7). The stone is light brown, coarse-grained, and gritty in places. The same stone has also been quarried at two or three places around McGees Mills.

LIMESTONE

Limestone fragments were seen at many places, mainly the Upper Freeport limestone. The Brush Creek limestone, 2 feet thick and yellow, crops out in the railway cut at Mayes (De2). The limestone under the E coal has been quarried 2 miles east of Mahaffey. It is a compact, hard, light-gray limestone. It is reported to have been mined and burned 1 mile northwest of Glen Hope (Fe31). Other places where the Upper Freeport limestone was seen as fragments or reported include 1½ miles southeast of New Millport (Fc51); 1½ miles east of New Millport (Fc57); 1½ miles north of New Millport; 1½ miles northeast of Ansonville (Ed15); 1½ miles southeast of Grampian, Db 8 and Db9.

Fragments of limestone under the Lower Freeport or D coal were noted 1½ miles southeast of Curwensville (Fa52). At Fb10 the limestone is 3½ feet thick on the north side of the entry and is lacking on the south side. Limestone fragments were noted at Ca8, Fe11, and Ec18.

From what was seen, it was judged that limestone would have little value in this area. The localities mentioned might be further tested with the drill back from the outcrop, but the outlook is not promising. Some of the limestone might pay to mine in a small way for liming the land.

OIL AND GAS

The widespread occurrence of oil and gas in western Pennsylvania has led naturally to the hope that these fuels would be found in this region also. A study of the results of drilling in Pennsylvania indicates quite clearly that no oil may be anticipated in this area. An oil and gas map of Pennsylvania shows that oil is confined to the region west of a northeast-southwest line that lies not far from Clarion and Kittanning and extends southwestward to the State line a little east of the Monongahela River. East of that line gas is found in abundance but no oil. Experience has shown, as has been pointed out by David White,[1] that where coal occurs in the series of rocks in which oil and gas are sought, oil does not occur where structural conditions have been such as to raise the percentage of fixed carbon in the "pure coal" of the coal beds to more than 65 percent. That condition holds true in this region.

The Pennsylvania oil and gas map shows that gas is found east of the line just mentioned, but sparingly east of a line through Punxsutawney and Greensburg. Gas has been found in fair abundance on the Punxsutawney quadrangle just to the west; so that the possibility of gas on this quadrangle cannot be denied, but the indications are not favorable to large fields or a large production. The sands in which gas might be anticipated would seem to be the Murrysville (?) at the base of the Pocono about 1,100 feet below the Upper Freeport coal, and the Speechley 1,500 feet lower, or in the Oriskany sand about 7,800 feet below the Upper Freeport coal. It should, of course, be understood that prospect drilling in areas east and south of this quadrangle have not been encouraging.

MINERAL RESOURCES MAP

Introduction. Under the heading of Mineral Resources four small-scale maps summarize our knowledge of the individual coal beds. Patterns indicate variations in thickness and degree of knowledge. The pattern "2 feet net" means two feet of coal after rejecting any benches likely to be rejected in mining. To keep the procedure uniform, all benches are rejected that are separated from the main bench by a parting or binder thicker than the smaller bench of coal.

Plate IV shows more accurately the positions of outcrops and the location of datum points.

It is hoped that the rather explicit directions which follow will enable anyone to determine closely what rocks underlie any given tract of land, the depth and probable value of particular beds of rock.

For ready reference between the resource maps and text, Plate IV has been divided into six vertical and six horizontal rows of small quadrangles of 2½ minutes each. All of the symbols in each quadrangle are numbered. The vertical rows of quadrangles are designated by capital letters and the horizontal rows by small letters. Thus, Cd16 refers to datum point 16 in the third vertical row from the left and the fourth horizontal row from the top.

Pattern Ccm. The area covered by this pattern is underlain by the horizon of the Upper Freeport coal and all of the rocks below that horizon, as shown on the stratigraphic chart. The edge of the pattern gives the position of the Upper Freeport coal and its underclay and the Upper Freeport limestone, if present. These beds are so thin and close together that, on the scale of this map and for practical purposes, they may be represented by a single line. The altitude of the coal, clay, and limestone at any point along their outcrop is shown by the position of the line on or between the light-brown contour lines.

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[1] White, David, Some relations in origin between coal and petroleum: Washington Acad. Sci. Jour., vol. 5, pp. 189-212, 1915.

The depths of those three beds within the area of the pattern may be determined by subtracting the altitude shown by the red structure contour lines from the altitude of the surface at the point in question. Suppose, for example, it is desired to know the depth of the Upper Freeport coal below the crossroads at Marron, near the center of the map. The map shows the crossroads is between the 1,800 and 1,820 contours. Its elevation is, therefore, about 1,810 feet. The 1,600-foot structure contour line passes just north of the corner, and the spacing of the lines suggests that 1,610 feet is the altitude of the coal. Subtracting 1,610 from 1,810 gives 200 feet as the depth to the E coal at that point. The depth to that coal at any other point within this pattern may be found in the same way. The depths to any other beds above or below the E coal may be found by measuring the vertical distance above or below the E coal to the other bed on the vertical section on the stratigraphic chart and adding to the depth found for the E coal, if the rock in question is below the E, or subtracting from the depth if it is above the E.

Within the area covered by the broad patterns are smaller areas within which crop out massive, coarse-grained quartz sandstones, possibly suitable for rough masonry purposes, such as foundations, bridge abutments, and some stone suitable for structural purposes. The color pattern and the letter symbols serve as a key to the stratigraphic position of the sandstone at any point if that information is desired.

Where their presence is indicated by outcrops, the positions of the Bakerstown and Brush Creek coals and other beds are shown. Where these are not shown, their possible position at any point may be determined by calculating the depth to the Upper Freeport coal as before and then measuring up from the position of that coal in the columnar sections, an interval equal to the depth of the coal. All the rocks within that space should be found if present. Thus, if the Upper Freeport coal, at a point in question, is 150 feet below the surface, 150 feet measured up from the E coal on the stratigraphic chart will include the various parts of the Mahoning member and the Brush Creek coal, but not the Cambridge limestone, Bakerstown coal, and higher rocks.

Pattern Ca3. The area underlain by pattern Ca3 lies between the outcrops of the E and D coals. The outer edge of the pattern has the position of the D coal and clay and of the Lower Freeport limestone where present. The area should be underlain by all the coals and other rocks from the D bed downward. In this area the E bed is wanting. Its theoretical position, if it had not been eroded, is shown by the structure contours. The depth to any stratum of rock below the D can be determined as previously outlined.

Pattern Ca2. Pattern Ca2 covers the outcrops of the rocks between the D and B coals. Its outer edge defines the position of the B coal and clay. This area is underlain by the B coal and all the rocks below. Also it is in part underlain by the C′ coal and a larger part is underlain by the C coal. The outcrops of those coals, marked U.K. and M.K., are shown over part of the area. The depth to any rock below the B may be approximated by the same principle as was used in the description of the first pattern.

Pattern Ca1. Over the area of pattern Ca1 the B coal and all the higher beds have been removed by erosion but the area is underlain by the A coal and lower rocks, the depth of which may be determined as above.

Pattern Cpv. Pattern Cpv covers the area of outcrops of the Pottsville rocks, including that of the Mercer clay, the position of which is shown by the blue line marked M.cl. In general, the area of this and the next pattern may be considered as outside the area of the workable coals. Possible values within the area of this pattern would consist of the sandstone and, where present, of the clays at the Mercer horizon.

Pattern Cmc. The sixth pattern, Cmc, confined to the valley of Anderson Creek, covers the area of outcrop of the Mississippian rocks, including the red shales and sandstones of Mauch Chunk and Pocono age.

To determine what mineral resources underlie any particular point or area. Note first the pattern covering the point or area in question. The patterns indicate in a general way what portion of the columnar section remains and what has been removed. Knowing what strata are under the point or area, the character and value of the various deposits and their position may be determined from the resource charts and accompanying text. Thus, suppose it were desired to know what underlies Ansonville in Jordan Township. First, it may be noted that it is in the area of pattern Cem and that the corners are above the Upper Freeport coal. A comparison of the elevation of the corners (1678) with the elevation of the Upper Freeport coal, as given by the structure contours, shows that bed is only about 50 feet deep (1678-1625). By the stratigraphic chart, it would appear, therefore, that all the strata from just above the Upper Freeport coal downward should be met by a drill hole. On Figure 15 the sections nearest this point are 30 to 33. These sections (Figure 16) range from 2 to 5 feet, indicating a coal of variable thickness. Under such circumstances, it would be well to play safe and assume only the lowest thickness, 2 feet, until drilling shows the coal to be thicker.

About 40 feet below the E coal should be found the D bed. As shown on the resource chart, its thickness in this area is above 2 feet. Sections 84 and 89 on Figure 18 indicate a coal averaging 30 inches or better, but variable. Turn to the description of Jordan Township. The underlying coals, the C′, the C, the B and A, have been prospected so little in this immediate neighborhood that no accurate judgment of their thickness can be given. Judging from all of the sections given, it may be anticipated that the C′ and C beds are thin, though possibly of future workable thickness, the B bed also thin but more likely to have a workable thickness, and the A bed variable with possibly a thickness of 3 to 4 feet but with just as great a likelihood of being one foot or less. Of the sandstones, none may be counted of any value. The clays may be worked by underground methods and may be valued in the same way as the coals. It is probable that at least three or four clays under Ansonville are of workable thickness and quality. No value can be assigned to the limestones or shales under that point.

The same method of judging the mineral values may be used for any other point.

As to the often-asked question, "What is a bed of coal worth?": The answer depends so largely on the transportation facilities, character of the coal, depth, market, etc., that no reliable judgment can be given. For a 5-or 6-foot bed in this area, lying close to transportation, it may be estimated that, if leased, it should be worth about 10 cents per ton of recoverable coal or, to be conservative, $100 per per acre-foot, that is, for each foot of thickness in an acre. The owner, of course, pays the taxes on the land, and gets his pay as the coal is mined out. If the land or the coal rights are sold outright, they may be estimated to be worth, under the conditions named, about one-tenth of the figure given. If the bed is less than 5 or 6 feet thick, the cost of mining is higher, the cost increasing rapidly with the decrease in thickness so that a 3-foot bed may not be worth more than one-half, for each foot of thickness, the value of each foot of a six-foot. The methods used in valuing the public coal lands are discussed in Bulletins 424 and 537 of the U. S. Geological Survey.

WATER RESOURCES

The mean annual precipitation on the area as determined from the records for Altoona, Clearfield, Ebensburg, and Punxsutawney, by the Theissien method, is 42.50 inches. In this calculation the Clearfield record carries about two-thirds the weight of the four station records.

The precipitation station at Clearfield was established in 1905. To 1913, inclusive, the yearly records were broken; however, since that time, with the exception of 1925, the records are complete. The mean annual precipitation for the period is 43.98 inches. The maximum yearly amount recorded at the station was 60.88 inches in 1921, and the minimum was 29.32 inches in 1930.

The precipitation records for Pennsylvania are published in detail by the United States Weather Bureau in their monthly and annual Climatological Data.

A stream flow gaging station was established on the West Branch of the Susquehanna River at Bower in 1913, where the drainage area is 315 square miles. The mean annual discharge at the gaging station has been 564 second-feet. The maximum discharge was 31,500 second-feet in March, 1936. The minimum flow was 16 second-feet in September and October, 1930. The gaging station records are published in the reports of the United States Geological Survey and of the Pennsylvania Department of Forests and Waters.

The maximum run-off is usually in March or April (though not always). The run-off through December to April, inclusive, is usually above the average and for the rest of the months, below the average. December, January and February may, however, all run under the average, especially when the river has remained frozen; occasionally May or June or some other month may run above the average. The summer and fall months, although generally below the average, are variable from year to year; thus the October run-off in 1896 was more than 13 times that in 1899.

Ground Water

The ground water is that which permeates the ground. It runs out as springs, is taken up by plants, or is raised from wells for household or other uses. Rain water descends into the ground along fractures or porous portions of rocks until it reaches either an impervious stratum or the level of saturation or water table. The impervious strata encountered in this area are most commonly the beds of clay that underlie coal beds. Reaching such a layer, the water may follow it down the dip to its outcrop, where the water escapes as springs. If, on the other hand, it first reaches the water table, it tends temporarily to raise the level of that table, causing increased outflow in the valleys where the water table reaches the surface. The underground waters move in the same direction as the surface waters. In a general way, the water table follows the topography of the surface, though it is less rugged in shape. As a rule, it is near the surface in the valleys, and is farthest from the surface on the hills. The depth of the water table varies with the character of the surface, the character of the underlying rock, and the season. It will be nearer the surface in broad flat areas than near sharp declivities where the water may drain away readily. It will be nearer the surface underlain by fine-grained rocks, such as shales, than one underlain by coarse-grained rocks like sandstone. The water table rises rapidly after heavy rains and then gradually sinks again as the water drains away.

In this area a large percentage of sandy strata, sandstones and sandy shales permit a large absorption of the rainfall. This equalizes to some extent the stream flow in summer. During rainy weather and for a time afterwards the streams carry more or less water that has flowed down the surface without entering the ground. During the drier seasons, practically all the stream run-off is derived from underground circulation.

Domestic Supplies

Domestic supplies in this area, aside from public supplies, are derived from wells and springs. The wells are either dug or driven, mainly the former. The dug wells range, as a rule, from 10 to 30 feet deep. The driven wells in a few instances are nearly or quite 100 feet deep. The springs generally have a small flow; a few large springs are used for town supplies.

The water of this region is soft and healthful. Many of the springs come from coal beds and may contain a high percentage of "sulphur" derived from the coal. Water from a few springs is piped into houses below and, if the flow warrants, modern fixtures are installed. In a few places windmills and elevated tanks have been installed to provide running water in the homes. So far as was learned, the supply of water is abundant at all seasons.

Public Supplies[1]

Curwensville is one of the few towns supplied from surface waters.

Ansonville is supplied by the village from several small springs in the lower part of the Conemaugh formation. The water is distributed by gravity from a 15,000-gallon reservoir. About 150 people are supplied, and the water does not require treatment.

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[1] Lohman, S. W., Ground water in south-central Pennsylvania: Pa. Geol. Survey Bull. W 5, pp. 193-4, 1938.

Coalport (population 1,222) is supplied by the borough from two drilled wells. The turbine pumps in the wells discharge the water through an aerator, after which the water is treated, chlorinated, filtered, and pumped through the mains to the reservoir by two centrifugal booster pumps, each having a capacity of 80 gallons a minute. The reservoir, which is made of concrete and holds 100,000 gallons, is on a hill east of the borough. The average daily consumption is about 50,000 gallons. There are 40 fire hydrants. The maximum pressure is about 80 pounds to the square inch.

Eight homes and a hotel in Grampian (population 533) are supplied by gravity from a small hillside spring owned by Fred Snyder, and it is reported that two other groups of homes are supplied from two similar springs. The waters do not require treatment.

In Mahaffey (population 667) 25 families are supplied from three small springs owned by S. C. Mahaffey. The springs, which are on the hills east of the borough, discharge into one large and two small reservoirs, and the water is distributed by gravity without treatment. The supply is reported to be inadequate in dry weather.

Some spring water is used by Lumber City in addition to water from the river. About 200 people in Bell Township are reported as supplied with spring water by the Rocky Springs Water Company.

The Pottsville formation is the most productive water bearer in the county. Several wells less than 150 feet deep drilled into it where it is near the surface yield from 3 to 100 gallons a minute.

The sandstones in the Allegheny group are next in importance. The Conemaugh group is relatively unimportant as a source of water.

Ground water for industrial or public supplies is recovered largely from drilled wells. Flowing wells occur in the synclines. In general, the water is good except for objectional amounts of iron. Most of the ground waters are soft or only moderately hard. Some of the Pottsville waters are hard. Additional information will be found in Pennsylvania Geological Survey Bulletin W5, Ground Water in South-central Pennsylvania.

Deep wells and artesian wells

Artesian water conditions should be found in the valleys in the axes of all of the synclines in this area. Such water should be looked for in the underlying sandstones that crop out or are exposed above drainage on the anticlines. One such artesian well has already been obtained at Lumber City. Other artesian wells have been found in this general region, as, for example, the one just west of Osceola Mills 12 miles east of this area. The water in such wells is likely to be mineralized, as shown by a well in the Curwensville syncline sunk near Clearfield. That well found a weak brine between 400 and 500 feet below the surface and a strong brine between 700 and 800 feet. A gallon of the water weighed 8¾ pounds and contained 2/3 of a pound of salt, 84 gallons being required to furnish a bushel of salt. Analyses by Geo. H. Cook, of New Jersey, as given in the Second Geological Survey of Pennsylvania report (H7, p. 140) is as follows:

Analysis of brine from Clearfield "oil" well

Common salt	69.010
Chloride of bittern, calcium	25.090
Chloride of magnesian bittern	5.900
	100.000
Water	88.952
Salt	7.591
Chloride calcium	2.767
Chloride magnesium	.655
Oxide of iron	.007
Silica and earth	.028
	100.000

Water power and water storage

At the present time this area holds out little inducement for water-power projects of any size. A few places, to be mentioned later, may prove worthy of study in the future, particularly in connection with any scheme of water storage. Present interest will probably be in the possible utilization of some of the small streams of the region in the production of small quantities of power for local domestic use. In many sections of the country small streams are being used for lighting individual houses or groups of houses and for running machines on the farm and in the house. In many parts of this area the streams rise on the upland and may flow from one to several miles before descending sharply to the main valley. Such streams have a very small flow at most times and may be dry during drought, but, as the fall may amount to 100 or 200 feet in a quarter of a mile, it would seem that such streams might well be utilized in a small way by those through whose lands they flow.

In any discussion of water power it must be recognized that in any region situated as this is, in the heart of the coal field, with cheap coal everywhere available, water power cannot compete with the coal because of the large cost of installation except where the conditions for such installation are very exceptional. There are practically no waterfalls in the area, but low cascades occur where streams descend from the upland. To take advantage of such conditions involves always the building and maintenance of a long flume and of a penstock which, in most instances, will be expensive to build. The matter is presented here only as a suggestion.

Besides the many possible small developments, a few larger developments may be feasible in the future. As most, if not all, of these projects involve dams of considerable length, usually at least 1,000 feet long on top (for a height of 60 to 100 feet) which would yield only a very limited amount of power, the largest present interest in such places must be as possible sites for impounding dams for water storage for the benefit of stream regulation, larger power plants farther down the rivers, or for flood prevention. Among places of special interest in this line are:

Susquehanna River at Chest Falls (where the Bell-Greenwood Township lines crosses the river), between Bells Landing and Lumber City, and just below Lumber City. Dams on the river would be low because of human occupation of the valley.

Anderson Creek above Bridgeport.

Little Anderson (Cratcher) Creek above mouth.

Curry Run two miles from mouth.

None of the places mentioned was specifically examined for dam sites and the suggestions are made mainly from recollections of the conditions at those points, supplemented by data from the maps and from photographs.

At the present time there are a few water-power developments of very minor importance, such as that on Susquehanna River below Mahaffey.

MINERAL RESOURCES BY TOWNSHIPS

Beccaria Township

This township was named after the Italian philosopher, Marquis De Beccaria. The portion of this township in the quadrangle has long been the scene of active mining, mostly on the Lower Kittanning or B coal. The township is much cut up by the valleys of Clearfield Creek and of North and South Witmer runs. The Upper Freeport or E coal underlies the tops of the higher ridges, which are capped with rocks of the Conemaugh group. The A bed crops out a little above the creek bottoms, and the top of the Pottsville in the creek beds near and below Irvona. The rock structure in the township is characterized by a gentle southeast dip toward the axis of the first or Moshannon basin. The Laurel Hill anticline follows closely the northwest edge of the township with a low saddle between Comfort Run and McCartney.

The lower Conemaugh coals crop out in the southeast corner of the quadrangle. Though no openings were found on these beds, the many outcrops observed indicate persistent beds, which may be of a thickness to invite mining in the future.

The Upper Freeport coal has been opened in the ridge tops north and south of Glen Hope (Fe31, Fe27, Fe21, Ff8) and everywhere shows from 28 to 30 inches of solid coal. The Lower Freeport bed has been mined at the Blue Run Mine, Fe25, and other openings near Glen Hope. It is a little thicker than the Upper Freeport, averaging about 3 feet thick and usually solid.

On the old Dr. Caldwell's place overlooking Glen Hope, the Lower Freeport coal, 2 feet 8 inches thick, is underlain by 2 feet of clay and that by a hard, compact, blue-gray crystalline limestone, reported to show an analysis of 93.81 percent calcium carbonate, 1.71 percent magnesium carbonate, .53 percent sulphur, .008 percent phosphorus, and 2.07 percent insoluble residue. At the Hiram Swank and Son's No. 9 Mine the E bed is 3 feet 4 inches thick, including a 2-inch binder 21 inches from the bottom.

When this study was made, little information was available on the coals between the D and B. The evidence at hand indicates the presence of three beds, of which the uppermost or C′ is the most valuable.

This bed, which is from 35 to 45 feet below the D, is from 2 feet 6 inches to 3 feet 6 inches thick. It was seen on Porter Run, having the smaller thickness indicated, where it is overlain and underlain by shale. It is reported to be 3 feet thick near Glen Hope. The C bed is from 45 to 56 feet lower and everywhere reported thin, from 14 to 28 inches, though Mr. Gaskin reports 3 feet 6 inches in prospect holes dug near the mouth of Witmer Run. This bed is 28 inches thick at the Glen Hope mine, Fe96. A bed 10 inches or more thick is reported from 14 to 30 feet above the B and may be the equivalent of the Bens Creek bed farther east.

The Lower Kittanning or B bed has been mined extensively on both sides of Clearfield Creek at Irvona, Blain City, Rosebud, Coalport and to the south, as well as on South Witmer Run. As mining has been active here for three-fourths of a century, the minable coal must be approaching exhaustion, though several mines are still active.

This field opened up about 1883, when the Bells Gap Railroad, formerly a narrow-gauge railroad, was widened to standard gauge. The first mines opened were Sykes and Jones, Elliot, Bryson and Richard, and Irvona Coal Co. (Gaskin, Loysock & Co.).

The bed lies about 100 feet above the railroad at Irvona and 80 feet at Coalport. The bed is thick but extremely variable, as shown by the Lower Kittanning coal sections, Figures 31 to 39A. The coal is locally involved in faulting. In the faulted zone mining is difficult or impossible. As a rule, the top bench, in which most of the variation occurs, is from 8 to 26 inches thick. Below it is a bony parting from 4 to 9 inches thick, then a lower bench which may be solid coal 30 inches thick or in two or more benches of varying thickness. The bottom bench is 6 to 10 inches thick and separated from the coal above by from 6 inches to 3 feet of clay. Toward the north the parting between the main benches increases until in places it is said to be as much as 16 feet thick. At the Hyle Mine (Ef17) the parting is 9 feet thick. In places near the fault, the coal is thickened by squeezing to as much as 9 feet. In general, the roof section shows: sandstone, black shale 9 to 10 feet, and clay from a thin film to 8 feet. In places sandstone rolls come down, leaving the clay thin. This clay roof is very difficult to support.

The fault previously mentioned appears to extend from south of Frankhurst to and beyond Blain City. It has a direction south 56° west, with a spur extending southward into Oakland No. 2 Mine. The fault zone is exposed in a cut for an electric tram in the north part of Blain City (Fig. 32). Faults in mines near McCartney suggest that faulting may be common in this district, as they are on the Houtzdale quadrangle at the east.

Below the B bed are the A and A′ coals. In a section just south of Irvona the coal appears to be in several splits ranging through 40 feet of strata. The A bed has been mined at the Glen Brook Mine (Ef32), being from 4 to 6 feet thick, but variable. In parts of the mine the bed shows 3 feet of solid coal overlain in order by 11 to 12 inches of sandstone, 1 foot of coal, 5 to 6 inches of bone, and more sandstone. Normally the coal is underlain by from 2 to 6 inches of bony coal and shale, then 6 inches of coal and fine clay below. In places near rolls, the bed is reported split by clay partings 6 to 12 inches thick, making it practically valueless.

Massive, gray sandstone, assumed to be the Homewood, crops out in the bed of Clearfield Creek for some miles above Glen Hope.

Sandy limestone is reported at 168 feet above the creek between Irvona and Coalport; also thin layers of carbonate of iron, totalling a foot or more, which analyzed 34 percent iron.

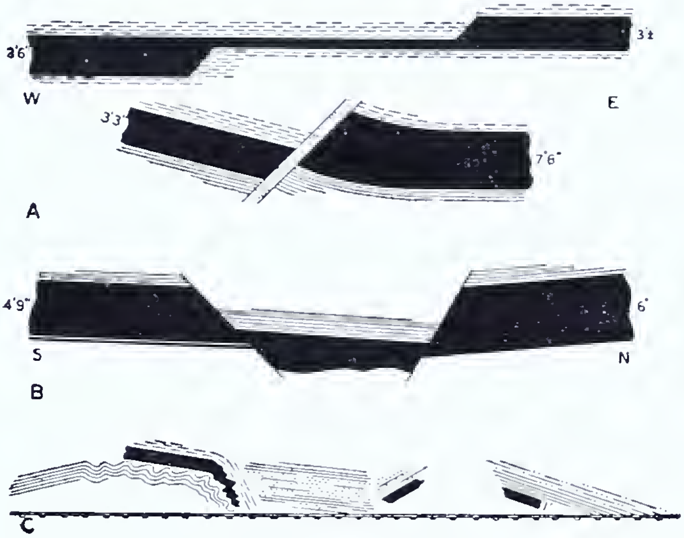

Figure 32. Sketch of "faults" at Blain City and near McCartney.

A. In Porter Run No. 1 Mine, Fe2.
B. In Pennsylvania Coal and Coke Company Mine, Fe8.
C. In cut beside tram from mine to tipple at Ff13, Irvona Coal and Coke Company's Mine.

Bell and Brady Townships

The description in this paragraph applies only to the eastern part of Bell Township and the southeast corner of Brady Township, as indicated on the map of the quadrangle. This includes the district around Mahaffey and Ostend and northward past Rowles to the headwaters of Beech Run. Bell Township was named after the Bell family, of whom the first settler was Arthur Bell, Jr. The McCracken and Mahaffey families came a little later. Brady Township was named for Captain Samuel Brady, Indian fighter and hunter. The township was first settled by James Woodside in 1785. Much of the district has high relief and is given over to timber. The valleys of the West Branch of Susquehanna River and Chest Creek unite at Mahaffey and give passage to branches of the Pennsylvania and New York Central railroads, and to important highways. Because of the timbered character of much of the land and the fact that many of the hilltops are capped by massive sandstone, of which fragments mantle the lower hill slopes, outcrops are not abundant in the north half of the area, and very few openings have been made to coal beds or to other mineral deposits in that region.

The Chestnut Ridge anticline crosses the north part of the area where the Upper Freeport coal reaches an elevation of 2,100 feet above sea level, and is caught by only a few of the hilltops. Toward the south the dip brings the Upper Freeport or E coal under the crests of the divides so that around Mahaffey it underlies the hills at about 1,500 feet above sea level, a descent of 600 feet in 4½ miles. Near Mahaffey the top of the Pottsville is exposed in the bottom of the valley, and the same condition holds in the deeper valleys all through the district. For that reason, the Allegheny group crops out along the flanks of the valleys and, where exposed, the coal beds show as black lines nearly parallel with the stream bottoms. The Brookville and Clarion coals commonly crop out low on the valley sides, the Kittanning beds along the middle of the valley banks, and the Freeport beds near the tops of the hills.

The Upper Freeport or E coal appears to be of minable thickness throughout most of the district. On the divide between Fryor and Beech runs in the northwest corner of the quadrangle this bed has a thickness of 3 feet 6 inches to more than 4 feet, and has several thin partings (Aa1 and Aa4). Near the head of Beech Run it consists of 2 feet 8 inches of solid coal (Aa6). It is cut out over most of the headwaters of Curry Run.

In the same area the D coal, also confined to a few hilltops, consists of from 2 feet 4 inches to 2 feet 8 inches of solid coal (Aa, west of, and Aa7). The Middle Kittanning coal, seen only at one place, showed only a few inches of coal (Aa8). The Lower Kittanning or B coal, seen on Irish Run (Aa9), has a thickness of 2 feet 5 inches of solid coal.

Between the headwaters of Haslett and Laurel runs no measurable exposures of coal were found. The Upper Freeport bed appears to underlie the divides with less than 100 feet of cover.

Around Mahaffey there have been a number of commercial mines on the Upper Freeport or E coal, the Lower Freeport or D, and on the Brookville or A coal. Outcrops of the Brush Creek coal were noted at a number of places, but the indications are that this is not a workable bed. The D coal has been mined in the Howard No. 1 mine, 160 feet above the New York Central track (Ad16). The coal is from 2 feet 6 inches to 3 feet 8 inches thick, averaging about 3 feet, with a parting near the middle which averages about 3 inches, and a sandstone roof. The B coal crops out just at railroad level. A little farther south, near Ostend, the D bed has been mined by the Mahaffey Coal Mining Company at the Mahaffey No. 1 mine (Ad17). Here the coal is in two benches, the upper averaging 14 inches, the lower 12 inches, with a 4- to 6-inch binder. The roof is sandstone, and there are 3 to 4 feet of clay beneath the bed. The E coal, 16 inches thick, is reported to be 40 feet above the D bed. On the east side of Chest Creek the E coal, 3 feet thick, has been mined (Ad5). The roof is a clay shale, and the underclay, which is 3 feet thick, contains some flint clay. The coal here is considerably disturbed. The face of the coal lies N. 85° W. The B coal has been opened at Ostend (Ad4) about level with the railroad. The coal measured 2 feet 8 inches near the outcrop and thinned to 1 foot 10 inches on the rise. It is reported to reach

3 feet 3 inches locally. The Butler sandstone between the E and D coals is a coarse-grained, fairly massive, gray to brown sandstone, gritty in places. It might be of value for rough building purposes. The Lower Kittanning or B coal has also been opened near railroad level at several places from one-fourth to half a mile north of Ostend (Ad7 to 10).

At Mahaffey (Ac4) the B coal is 1 foot 10 inches thick and solid, overlain by 12 feet of light brown, thin-bedded sandstone. Below the coal is 8 feet of light drab clay with 6 inches of poor flint clay 3 feet from the top. The Middle Kittanning or C coal lies about 40 feet above the B coal (Ac3). The bed consists of 13 inches of coal overlain by 2 feet of bone and bituminous shale, 10 feet of drab, fissile shale, and 6 feet plus of shaly sandstone. Under it are 4 inches of drab shale and 4 feet 6 inches of drab to brown clay, good at the top but sandy toward the bottom. The Brookville or A coal goes below river level just west of the west edge of the quadrangle. It has been mined at the Kelly mine, and at other mines farther west. It has a thickness around McGees and to the west of about 4 feet. It is overlain by a massive sandstone (the Clarion) which has been quarried and shipped for building stone near McGees, or ground for building sand at the same point. The same bed has been quarried at Chest Falls (see Figure 11A). The B coal is seen at a number of points between Chest Falls and Mahaffey. Near the falls (Ac9) the bed is from 2 feet to 2 feet 4 inches thick and has a shale roof. The E coal has been mined on the south side of the West Branch on the Stevenson land. The coal is 31 inches thick. The Mann Coal Company was mining the D bed in 1930 (Ac12). This bed consists of 2 feet 8½ inches of coal with 2 inches of bone and coal on top and 4½ inches of bone and coal underneath. It is overlain by gray shale and underlain by clay.

In 1938 the following section was exposed at a new roadside quarry (Bd12):

Section between Ostend and La Jose

	Feet
Chip shales, suggestion of coal at top	25
Clay, drab, black at top (coal horizon?)	2
Covered	8
Clay, hard, sandy or clayey sandstones	8
Sandstone, irregularly bedded (Clarion?)	12+

From the above it is evident that there is little coal under the valleys unless the A bed proves to be workable in this region. This would readily be shown by drilling. It will be close to water level around Mahaffey, and but little above water level in the valleys to the north. The Mercer beds appear a short distance west of McGees, and may possibly reveal some workable coal. The other beds appear to be thin, but should contain a large amount of coal for future mining. Beds E, D, C and A have thicknesses of from 2 feet to 3 feet 6 inches. The clay under the E and B coals in particular may be worthy of investigation. The Clarion sandstone has been quarried in the past and may prove of value in the future. Traces of flint clay show at the horizons of the E, B, and A beds. The Chestnut Ridge anticline in the northern part of this district may prove to be gas bearing. Some gas has been obtained in drilling in the western part of Bell Township.

Burnside Township

The east half of Burnside Township, including New Washington borough, is a broad upland under extensive cultivation. It falls off sharply on the east to Chest Creek and its western tributaries. Outcrops of the Brush Creek and Bakerstown coal are seen in places, as at Ae2 to 11. The Mahoning sandstone, though nowhere prominent, is sufficiently massive to appreciably affect the topography, causing bold interstream divides facing Chest Creek, and low gradients and broad stream valleys above its outcrop in contrast with steep gradients and narrow valleys below its outcrop. The E coal crops out on the flanks of the hills, 150 to 300 feet below the higher points of the divides. A number of mines have been started in the township, but in general the coal has been thinner than expected, and most of the mines did not operate long. No evidence of minable coal in the horizon of the Upper Freeport or E bed was found. The D bed has long been mined west of La Jose at Lee Hollow. The coal is from 2 feet 8 inches to 3 feet 8 inches thick with a ½ to 1½ inch binder 8 inches to 12 inches from the bottom. The roof is shale and 6 inches of draw slate that usually holds over the thin coal, but falls over the thicker coal. West of Waukesha the D bed has a thickness of 3 feet (Be20, Be10). Near Welshdale its thickness is 2 feet 6 inches (Bf7) and near Westover 2 feet 8 inches (Bf15). From these sections it would seem that the township is underlain by an extensive body of D coal of thin but minable section. Drilling, however, is said to have shown little coal of value at this horizon in the township.

The Upper Kittanning or C′ coal has been mined near New Washington (Bc2 and 3), where it has good thickness but is badly split up. There the main coal is in five benches, ranging from 6 inches to 1 foot 4 inches thick, with partings from ¼ inch to 4 inches thick. Underlying the coal there is from 1 foot 5 inches to 3 feet of shale, 9 inches to 20 inches of coal, 2 to 3 feet of clay, and finally laminated sandstone. The roof is good, consisting of 3 to 4 inches of draw slate. The sections vary greatly from place to place. In Lee Hollow the same bed has a thickness of 2 feet 2 inches of solid coal overlain by 14 inches of shale and 6 inches of coal. On Spring Run the coal has a thickness of 6 feet 6 inches, about the same as at St. Lu, and, like the coal there, is split up into many benches. Assuming these sections to be characteristic, it would appear that there is a large body of coal at this horizon, but it is so badly split up as to be of very doubtful value. Flint clay and limestone occur in the Westover region under this coal. The Middle Kittanning or C bed along Chest Creek is a solid coal from 2 feet to 2 feet 7 inches thick. Therefore, it is probably of minable thickness under part of the township.

Little is known of the Lower Kittanning or B coal. The sections along Chest Creek near La Jose and Welshdale show from 2 to 3 feet of coal, and suggest that it is thin under this township but minable locally. Sections of the A coal show from 10 inches to 2 feet of coal, and do not give much promise of commercial coal at this horizon. Nothing is known of the Mercer coal or clay in this part of the township.

Taken as a whole, this township (part in Curwensville quadrangle) does not appear to have much, if any, thick coal of good minable section, and very little coal that can be mined commercially, except for local consumption, until demand makes possible mining beds 2 to 3 feet thick.

Chest Township

The broad valley of Chest Creek crosses the western part of this township at about 1,300 feet above sea level and gives its name to the township. The high divide between Chest Creek and Clearfield Creek has an elevation of from 1,700 to 1,980 feet. Cultivated lands are confined mainly to the valley of Chest Creek and its principal tributaries and to the tops of the divides, most of the sloping land being timbered. Structurally, the rocks have low dips. The rocks lie nearly flat across much of the center and north parts of the township. The E bed ranges from 1,500 feet above sea level in the north corner to 1,800 feet in the southeast corner where the Laurel Hill anticline crosses.

The E coal lies 200 to 300 feet below the higher hilltops. The Brush Creek coal crops out in the railroad cut at Mayes. The E coal near Mayes is reported as from 2 feet 6 inches to 3 feet 7 inches of dirty coal, including a 3-inch bench 10 inches from the top (De1). At Ce16 the E bed is 2 feet 8 inches thick, including 1½ inches of parting 11 inches from the bottom. Between Westover and McPherron (Cf1 and 2) the E bed ranges from 1 foot 10 inches to 3 feet 6 inches. Where thickest, on the Ed Westover place, it has from 1½ to 2 inches of parting from 8 to 9½ inches from the top (Cf1). It is uncertain how much of this area is underlain with minable coal at this horizon. As suggested, however, on the sketch map it has been judged that the bed is not of minable thickness under most of the township.

The D bed is judged to be minable under most of the eastern and southern parts of the township. Its minability is judged from mines at Berwindale and near Westover (Cf5), where the coal is solid and has a thickness of 2 feet 7 inches with a shale roof and clay floor. At Df12 it is 3 feet 6 inches thick with a 1-inch parting 3 inches from the floor.

As in Burnside Township, the Upper and Middle Kittanning coals, the C′ and C beds, are of commercial thickness in this township. The C′ bed is characteristically broken up into a number of benches, while the C bed is usually of solid coal. Both beds have been mined on Wilson Run. The C′ bed has been prospected on the Hutton place (Ce14), where it shows 3 feet 1 inch of coal in four benches with three partings from 1½ to 2 inches thick. At the Smith mine (Ce3) there is 3 feet of coal in a single bench, with a 7-inch bench above and 10-inch and 4-inch benches below, the partings, all shale, being 3 inches, 2½ inches, and 8 inches. An opening on the same bed at Ce8 showed 2 feet 6 inches of coal in three benches, with 3 inches of bone between the upper bench of 6 inches and the middle bench of 18 inches, and three-fourths of an inch of bone separating the coal from the underclay.

The C′ bed has been mined at the Jose and Mosher mine (Ce1), where the bed is 2 feet 8 inches thick with a 2-inch parting 4 inches from the top. The roof is sandstone and the floor clay. Farther up the valley the same bed has been mined at the Ames No. 1 mine of the Pine Ridge Coal Company (Ce7). Here the coal is from 2 feet 3 inches to 2 feet 8 inches thick, overlain by 8 inches of bone and 2 inches of coal. Above that are 1 foot 6 inches of shale and 10 inches of black shale or cannel coal. At the Elton mine of the Thomson-Lee Coal Company (Ce22) the coal is 3 feet thick, overlain by 4 inches of shale and 6 inches of dirty coal. The bed has been mined at the Bofast mine near Mayes (Ce23), where it is from 3 feet to 3 feet 4 inches thick, consisting of solid coal with 4 to 8 inches of bony coal as a floor. It is overlain by shale, and clay underlies the bony coal. On the point of the hill (Ce27) three coals have been opened at approximately 1,560, 1,590, and 1,615 feet. Though not open when visited in 1938, all were operating for wagon trade.

The C and C′ coals have been opened at many points near Waukesha and Welshdale. The C bed has been opened at a number of places (Be6, Be20, Bf6), at all of these averaging about 2 feet 6 inches of solid coal. The C′ coal west of the creek (as at Bf7) is thick but so much broken up with partings as to be hardly minable. East of the creek the C′ bed contains about 2 feet 6 inches of coal, but is split irregularly so as to have small value (Ce19). The C bed is a solid bed 2 feet to 2 feet 9 inches thick (Be16 and 18; Bf4 and 16). At Ce19 the coal of the C′ bed is 2 feet 6 inches thick. It changes from a solid bed to a bed having 6 inches of shale 14 inches from the bottom. East of Westover the C′ bed has one bench of 3 feet with a ½-inch parting 3½ inches from the bottom. Below the main bed are four other benches, the thickest of which is 9 inches.

The Lower Kittanning or B bed is of uncertain thickness under most of the township, but, judging from a few sections, may be counted upon to contain from 2 to 4 feet of coal under some of the township. It is from 2 feet 6 inches to 3 feet thick near La Jose (Bd7), including a 2-inch parting 4 to 5 inches from the bottom. The roof is sandstone and the floor clay. South of Waukesha the B bed is 2 feet 6 inches thick without parting (Bf5). On Kings Run, near Welshdale, this bed is reported to be 2 feet 2 inches thick. On the east side of the township the B coal has been mined by the Victor Collieries Company in the Black Elk mine opposite Comfort Run (Ef1), where the coal is from 18 inches to 3 feet 6 inches thick. The roof is sandstone and there are 2 to 3 feet of clay under the coal. The coal lies irregularly, dipping to the southwest.

The Brookville or A coal was seen at only three places in or close to this township. Along Chest Creek, near La Jose, the coal was only 10 inches thick, overlain by sandstone. West of Waukesha (Be19) it is 2 feet thick overlain by shale. The A coal has been mined on North Witmer Run northwest of Irvona (Ef32), where it consists typically of a main bed 3 feet thick. It is overlain by 13 to 14 inches of sandstone, 11 to 12 inches of coal, 5 to 6 inches of bone, and 8 feet of sandstone. The coal is variable in thickness and lies very irregularly.

Flint clay was seen in outcrop at a number of places around Westover. Some had been prospected, apparently without success.

Ferguson Township

This township, named for an early pioneer, John Ferguson, lies in the center of the quadrangle having its longer axis lying northeast and southwest. It includes Marron at the southwest, on a hilltop from which streams flow in every direction, and Lumber City at the northeast end. Most of the township is under cultivation, though very hilly. The bluffs facing the West Branch of the Susquehanna are steep. The other valley sides are less steep. The New York Central Railroad serves the northern part of the township, following the valleys.

The workable coal beds crop out on the lower flanks of the hills. The Bakerstown coal crops out at many places in the hilltops in the southern part of the township (Cd4, Dd1, 2, 3, 4 and 5). About 120 feet lower the Brush Creek coal crops out, as at Dd6. No measurements were obtained on either of these beds, but it was thought that neither is workable. The Upper Freeport or E coal is found at an elevation of about 1,600 feet above sea level over nearly all of the township, descending to nearly 1,500 feet in the western corner. Where seen, this bed is a little over 2 feet thick and solid, with a shale roof and clay floor (Dc9 and Dc14). It is doubtful if the bed is workable in the south part of the township.

The Lower Freeport or D bed has been mined extensively to the east of this township where, though thin, its quality permitted mining. Two openings show a thickness of 2 feet 9 inches (Dc22) and 2 feet 6 inches (Dd7). North of Little Clearfield Creek a single measurement showed 2 feet 4 inches with two thin clay bands (Ec22). It is estimated that the coal is of minable thickness over most of the township, probably becoming too thin to work in the southwest part of the township. A bed, 16 inches thick at Db39, is thought to be the C bed, while one at Ec27, 2 feet 6 inches thick, is thought to be the C′ bed. At Dd8 the C′ bed is 1 foot 8 inches thick, lying under sandstone. It is probable that each of these beds may prove workable locally.

Outcrops of the Lower Kittanning or B bed at Cc2 and Dc3 show from 14 to 18 inches of solid coal. Apparently this bed is thin, but there probably are many areas of workable coal in the township. It has an elevation of about 1,400 feet above sea level. A single outcrop of the A bed at Eb23 showed 18 inches of coal. The presence of workable coal at this horizon near Bells Landing suggests that more workable coal may be found in this position. The Brookville or A bed which is minable east of this area (east of Fc) appears to be thin in this area (Fe29, Fc7, Fc8).

At Lumber City the flint clay is 130 feet below the B coal and 40 feet below the A coal. The B coal and clay here show: coal 14 inches, soft clay 5 feet, shale 5 feet, coal 6 inches, clay 2 feet, and shale. At the Ross Mine, of the George S. Good Firebrick Company, the section as follows: sandstone roof; shale, variable but usually less than 1 foot; coal 6 inches; binder 1 inch; coal 2 to 3 inches; dark, shaly (low grade) clay 8 to 12 inches; black flint clay with some burly 2 to 6 feet; low-grade clay, 2 feet. At Db48 the Crescent Refractories Company is mining about 5 feet of hard flint clay which has a roof of 10 to 12 inches of coal and a sandstone floor. It is about 60 feet above the river. When visited in 1924, the main heading had been driven 1,000 feet with three sets of cross headings. At Db38 the Harbison-Walker Refractories Company is mining about 6 feet of clay, both black and burly, about 40 feet above the river. The roof and floor of this mine are sandstone.

The underclays of the E, D, B and A beds are all thought to be of possible value in this area, ranging in thickness from 4 feet to nearly 20 feet (Fb8).

Greenwood Township

This township, one of the last to be organized, was named for Greenwood Bell, one of the earliest settlers in the area. Greenwood Township lies on both sides of the West Branch of the Susquehanna River, centering about Curry Run and Bells Landing. The structure carries the Pottsville sandstone to or below river level, permitting a wider valley than is found above or below. The A coal lies just at or a little above river level. In the northern part of the township the E bed underlies the hilltops. In the southern part of the township the hilltops may be 300 feet above the E coal, and the area underlain by that bed is correspondingly larger. The structure of the northern part of the township is that of a monocline with a southward dip. The E coal drops from 1,950 feet above sea level in the northwest part of the township to 1,500 feet above sea level around Curry Run. The structure in the south part of the township is nearly level, with the E coal at just about 1,500 feet above sea level. Much of the township consists of steep, partly cultivated wooded hill slopes.

The Upper Freeport or E coal appears to be thin, but of future minable thickness west and north of Curry Run, northeast of Bells Landing, and around the head of McCracken Run in the southwest part of the township. The thickness north of Curry Run (Bb4), where it has a shale roof, is 2 feet 6 inches. Northeast of Bells Landing this bed is 2 feet 2½ inches (Cb14) to 2 feet (Cb21) thick. In the northern part of the township it ranges from 16 inches to 1 foot 9 inches (Bb2, Bb3). West of Hazlett Run the bed is 3 feet thick in three benches, with a ½-inch parting 12 inches from the top, and 2½ inches of bone 8 inches from the top. Three openings near McCracken Run showed thicknesses of 2 feet 2 inches to 2 feet 4 inches (Bc6), 2 feet 4 inches to 2 feet 8 inches (Cc6), and 2 feet 7 inches (Bc15). In the eastern part of the township the E bed has a thickness of 2 feet 3 inches (Dc9) to 2 feet 4 inches (Dc14).

The Lower Freeport or D bed is of moderate but minable thickness throughout the ridge northeast of Bells Landing, having a thickness of 3 feet to 3 feet 5 inches, with a characteristic clay parting 1 to 2 inches thick 4 to 5 inches from the bottom. The roof appears to be shale at all places, and the floor clay. (See sections at Db34, Cb20, and Cb23.) South of the river the only section seen (Be5) showed a 2-foot bed with a 1-inch parting 8 inches from the bottom. It is probable that in the south part of the township this bed is thin, but has many areas of 2-foot coal. A section of the Upper Kittanning coal north of the river (Be3) showed only 11 inches of coal, but one south of the river (Ce8) showed nearly 3 feet of coal with thin partings 16 inches from the top and 5 inches from the bottom. It is doubtful if either the Upper or Middle Kittanning will yield much coal from this township. The B coal underlies nearly the whole township. Sections indicate the bed is commonly less than 2 feet thick, though some 2-foot or more coals probably occur here. A section (Ae9) near Chest Falls showed 2 feet 2 inches of coal, and one down the river from Bells Landing (Cb22) showed 2 feet of coal. Other sections showed from 13 inches to 18 inches.

The Brookville or A bed crops out near river level and underlies practically the whole township, except the river valleys. At a small mine east of Bells Landing the coal is 2 feet 9 inches thick with a 1-inch parting in the middle. Near Curry Run (Ce12) the same bed is split into three widely separated benches none of which are workable. The Mercer coal and clay are below the drainage level or do not occur here at all.

In summary, the Upper and Lower Freeport are workable under small areas in the hilltops. The other beds are thin, though containing areas of coal 2 feet or more thick. The underclays are probably more valuable than the coals because of their thickness. There may be some flint clay a short distance below the drainage level.

Jordan Township

This township, named after Judge Jordan, is a broad upland into which the heads of Little Clearfield Creek, Potts Run, and North Witmer Run have cut valleys of moderate depth. As a consequence, the horizons of most of the coal beds of the Allegheny group underlie most or all of the township. The Upper Freeport or E bed underlies fully one-half of the township at depths of from 100 to 300 feet below the general upland level, dipping gently west. The Brookville or A coal underlies all of the township except the extreme south corner in the valley of North Witmer Run, where it is brought up by the Laurel Hill anticline. The beds lie nearly flat over most of the township. The Upper Freeport bed is below 1,550 feet near Mayes, but reaches about 1,800 feet in the east corner where it rises nearly to the crest of the hills. The E bed lies within 50 feet of 1,650 feet under two-thirds of the township.

The Upper Freeport or E coal appears to be of minable thickness all over the eastern half of the township. It reaches a thickness of 5 feet on the headwaters of Potts Run at Fd9 and Fd15. At the Sam Lamborn Mine (Fd9) the coal is 5 feet thick, not counting a 1½-inch bench at the bottom. The roof is shale and the floor clay. Fragments of limestone on the dump indicate the presence of the Upper Freeport limestone under the coal. At the Bloom Mine (Fd15) the same bed is 5 to 6 feet thick, but is overlain by 4 to 10 inches of bone. On

North Witmer Run the E coal has been mined, but appears thin at the outcrop. In the Ansonville area, the Upper Freeport limestone is reported to be 5 or 6 feet thick.

The Lower Freeport or D coal, though thin, is the principal coal worked in this township. It has been mined near Gazzam by the Clearfield Bituminous Coal Corporation. At the Gazzam Mines 1, 2, 3, and 5, the coal averaged about 2 feet 6 inches, ranging up to 4 feet, but being mined at a minimum of 17 inches. This was possible at one time (1903) because of the high quality of the coal, which brought a premium on the market. The roof is a light, reddish, brown fissile shale, and the coal is underlain by 2 feet or more of clay. In 1883 the only coal bank operating in the township was at Ansonville, where the bed showed two partings, one 17 inches from the top, the other 5 inches from the bottom. The same coal has been mined at Carnwath No. 2 Mine (Fd17), where it consists of 3 feet of clean coal overlain by 7 feet of rusty gray shale which thins out locally so as to let the overlying sandstone down on the coal. The underclay is 5 feet thick. (See section 83, Figure 18.) At Fd10 the D bed was mined by the Central Moshannon Coal Company and showed 50 inches of coal with one-half inch of bony clay and 1 inch of bone. The roof is a rusty clay shale and the floor is a soft clay under 6 inches of hard clay. At Fd33 this bed is 40 inches thick, underlain by 2 inches of clay and 3 inches of coal.

At McCartney two beds of coal have been mined, the two being only 12 to 15 feet apart. It was thought at first that these beds were the E and D close together. Later work near Madera showed that the D coal splits in that area and suggested that this was the D bed. The upper bed measured 2 feet 8 inches, but is reported to range from 2 to 5 feet under a sandstone roof. It is separated from the lower bed by 3 inches of white sandstone and a body of hard clay. The lower coal is reported to be from 2 to 5 feet thick, though, where measured by the writer, it was only 1 foot 11 inches with 1 inch of clay 3 inches from the bottom. The fact that the upper bed lies on sandstone instead of on clay, as is usual, suggests that the upper bed is the upper bench of the split D bed. Some of this clay has been reported very high in alumina. Under the coal there is 8 feet or more of limestone which is said to become dolomitic away from the outcrop. Apparently the same bed has been mined at the Porter Run No. 1 Mine (Fe2) in Beaver Township, where 63 inches of coal were being mined under a 7-inch rider bench. (See Figure 18, Section 94.)

On North Witmer Run the E bed has been opened at several places, lying about 80 feet above the creek at Berwindale and 350 feet above the creek at Comfort Run. There was no opportunity to measure the coal. The D bed at Berwindale lies 40 feet above the creek, while the C′ bed, worked at the Lakeside Mine (De15), is about at creek level (1518 A.T.). The latter is 3 feet 3 inches to 3 feet 10 inches thick (section 155, Figure 20). The coal is underlain by 6 to 8 inches of bone on a hard shale and clay floor. At the Berwindale No. 1 Mine (De16) the same bed is 5 feet thick, overlain by 1 to 10 inches of cannel coal and by shale.

Descending North Witmer Run, the coals arise over the nose of Laurel Hill anticline so that the A coal around Comfort Run lies about 60 feet above the creek and the B coal about 160 feet. The A coal has been mined in a number of places in the valley. Sections taken just south of the township line show a split bed having 2 to 3 feet of solid coal overlain by 1 to 2 feet of shale, 8 to 11 inches of coal, and 5 to 6 inches of bone. The B bed has been mined at the Black Elk Mine and other openings. At the Black Elk Mine (Ef34) the coal is reported to range from 5 feet 9 inches to 8 feet.

From what has been said, it is apparent that all of the Allegheny coals, except possibly the C, are workable in some part of the township. As all the beds underlie most of the township, it is quite possible that there is still a considerable body of coal to be worked.

Knox Township

This township was organized in 1853 and named after Judge Knox. Only the western part of the township is in the Curwensville quadrangle. The region is one of narrow, rolling uplands separated by valleys 200 to 300 feet deep with moderately steep slopes. The tops of the divides are underlain by all of the Allegheny coals, the E coal having a cover under many hills of from 100 to 150 feet, and the A coal cropping out at the base of the hills. The Upper Freeport or E coal is about 2 feet thick at the north (Fc56) and is nearly 5 feet thick with 8 inches of bone in the southwest (Fc35). The D bed appears to be minable under all of its outcrop in this area, the thickness ranging from 18 inches to more than 4 feet. Near New Millport it is from 3 feet 2 inches to 3 feet 6 inches thick (Fc48 and Fc53). The thickness increases southward to 4 feet 6 inches at Fd11.

After the completion of field work in this area, commercial mining was undertaken along Potts Run by the Carnwath Coal Company. At the Carnwath No. 1 Mine (Fd16) the D coal, at 1,530 to 1,550 feet above sea level, ranges from 3 feet to 3 feet 6 inches. On the northeast side of this mine the coal is fairly level at 1,745 feet. In this area the E coal, 2 feet 6 inches thick, lies 40 feet above the D coal. Carnwath No. 3 Mine was opened east of the creek in the B bed. The bed has a thickness of 3 feet 2 inches, including a 1-inch slate binder 17 inches from the bottom. Above the main bench is 3 inches of shale, 6 inches of coal, 6 inches of bony coal, and black shale and sandstone. Beneath the coal are 4 feet of clay. West of the creek the D bed has been opened at No. 4 Mine, where the coal is 3 feet thick with a 1-inch shale parting 12 inches from the bottom; and at the No. 2 Mine (Fd17) the coal is 3 feet thick, underlain by 5 feet of clay, and overlain by from 1 to 5 feet of shale, and by sandstone. At Erhard, where this coal was formerly worked by Berwind-White and John Taylor and Son, the bed is from 3 feet to 4 feet 6 inches thick and has a good shale roof. In 1924 W. A. Gould and Brother were operating the old Berwind-White Mine as Midvale No. 3 Mine. At least two beds have been mined here. It is uncertain whether these are the E and D, the E and upper bench of D, or the two benches of D. The section at Midvale No. 3, including both beds, shows: sandstone; bony coal, 9 inches; bony coal and shale, 6 inches; coal, badly streaked with shale and sulphur bands, 4 feet 6 inches; clay and stone, 18 to 23 feet; D coal, 2 feet to 4 feet 6 inches; and clay. At Midvale No. 3 Mine the two beds are 40 feet apart.

The Upper and Middle Kittanning coals appear to be thin, though the Middle Kittanning is nearly 3 feet thick near McCartney, south of the township. The Lower Kittanning or B bed likewise appears to be thin or lacking in much of the area. West of New Millport, however, the B bed is 2 feet 6 inches thick, and has been mined by the B. and B. Coal Company at their Sunshine No. 1 Mine. The roof is a heavy bedded gray shale. The Brookville or A bed has been mined east of Olanta. Around Olanta and to the west the coal is from 1 foot 1 inch Fe29, Fc7, Fc8) to 3 feet 4 inches thick. The coal is near water level on Little Clearfield Creek, and at or below water level on Potts Run.

Drilling near Carnwath has revealed in this area an abnormal condition similar to the condition near Clearfield. In these areas the Homewood sandstone is lacking and its place is taken by shales, coals, and clays with only a small amount of coal. At Olanta the A coal is estimated to be 290 feet below the E bed. At Carnwath the E coal is estimated to have an elevation of about 1,740 feet above the mouth of Carnwath No. 3 Mine. The same interval would give the A coal an elevation of about 1,450 feet, more than 50 feet below the creek. Drilling part way up the incline, the A coal was located at 1,485 feet. Less than 100 feet below the A coal the drill showed only 8 feet of sandstone, but 5 coal beds, 5 clay beds, and shale. Compare this with the section on Clearfield Creek below Dimeling.

Section on Clearfield Creek

			Ft.	In.
1.	Shale, dark		10	
2.	Coal, Brookville or A			10
3.	Clay (abundant flora)		6	
4.	Interval—3 feet black chip shale to 12 feet of sandstone		12	0
5.	Coal	1 foot 5 inches to	2	2
6.	Clay, drab	8 feet to	1	0
7.	Sandstone		4	0
8.	Shale, dark		2	
9.	Bone and bony clay		1	6
10.	Coal			3
11.	Clay, hard		3	0
12.	Shale, dark brown		9	0
13.	Coal			6
14.	Clay, gray		3	
15.	Sandstone, shaly		5	

The abundant flora in layer three was studied by Harvey Bassler and declared to be the same as at a mine on the Brookville coal at Pardoe, Mercer County, near the type locality of the Mercer coal.

Penn and Bloom Townships

Penn Township was first settled near Pennville in 1809 by Dr. Samuel Coleman. The name was given by a large settlement of

Friends. Bloom Township takes its name from the Bloom family, prominent among the early settlers.

This area includes practically all of Penn Township and the south edge of Bloom Township. The western part of Penn Township is little cultivated and mostly in second-growth timber. The eastern part has abrupt, steep-sided valleys, but much of the upland is rolling and under cultivation. Railway transportation reached Penn Township about 1883, permitting the opening of coal mines.

Structurally the rocks lie on the south flank of the Chestnut Ridge anticline, the Upper Freeport coal descending from 2,050 feet above sea level in the northwest corner to 1,600 feet above sea level at the south. The structure here has shifted from the usual northeast-southwest trend to a nearly east-west trend. Indeed, near Grampian the strike of the rocks is distinctly southeast-northwest.

The divide between Curry Run and Bell Run carries a large area of E coal which lies from 100 feet to nearly 300 feet below the hilltops. The divide between Curry Run and Haslett Run just catches the E coal in its highest points. The divide east of Bell Run is nearly all underlain by E coal, but in a narrow width and at fairly shallow depth. In the eastern part of Penn Township only small areas of E coal are caught in a few of the hilltops. The Brookville or A coal crops out in the valleys near the base of the flanking hills. The flanks of the hills therefore consist almost entirely of rocks of the Allegheny group, and nearly the whole area is underlain by the lower coals.

Little is known of the coal beds in western Penn Township. Many coal outcrops were seen, but the only opening is at the head of Bell Run, where the E coal (Ba3) had a thickness of 18 inches to 2 feet 8 inches, and the D coal (Ba4) a thickness of 3 feet 6 inches.

East of Bell Run the E and D coals have been opened in many places. The E coal crops out near the crest of the divide. In Bloom Township at one point (Ca2) it has a thickness of from 2 feet 8 inches to 2 feet 11 inches and has a shale roof and floor. The D coal at this point is only 18 feet below the E. The B coal was seen at a number of places in Bloom Township, but has not been mined. The A coal was mined at the north line of the quadrangle north of Hughey Run (Da2), where it has a thickness of 3 feet 6 inches to 4 feet. The Clarion coal, 2 feet 6 inches to 2 feet 9 inches thick, occurs only 19½ feet above the A; and 3 feet below the A there is reported to be 14 inches or more of coal. It is possible that these beds are all splits of the A bed. The Homewood sandstone immediately under the A coal is a massive bed of coarse-grained sandstone or conglomerate that makes the cliffed banks along Anderson Creek and has been extensively quarried just north of the quadrangle. (See Figure 11.) It is 40 to 50 feet thick. Blocks of any size desired can be cut from it. Under it is the Mercer fire clay which has been mined just east of this area.

Near the southeast corner of Bloom Township the Homewood sandstone crops out at the top of the slope west of Hughey Run. Here huge jointed blocks of the sandstone have slid eastward, opening up rooms and passageways, thus forming a rock city. (See Figure 12.) Many visitors are attracted here each year.

Grampian has long been a center of commercial mining. When first visited in 1903, the E bed was being mined at Priscilla Mines Nos. 2 and 3 of the Priscilla Coal Mining Company (Da7). The coal being mined was from 2 feet 10 inches to 3 feet thick and had no partings. It is overlain by 15 inches of black shale and by some gray shale. The D coal is only 16 to 18 feet below and reported as being 18 inches or more thick. Northwest of Grampian (Ca13 and 14, Da3) both the E and D beds are present, the two beds being reported 24 feet apart. The D bed has been mined by the Clearfield and Grampian Coal Company at three mines. It ranges from 4 feet 2 inches (Ca14) to 5 feet 7 inches (Ca13 and Da3) of solid coal. Where thickest, the bed contains two 2-inch clay beds respectively 14 and 25 inches from the top. The area underlain is not large and is confined to the crest of the divide. A small hilltop 1½ miles south of east of Grampian catches both the Upper and Lower Freeport coals. The D coal here (Da16), as under a wide area in the hilltops around Hepburnia, is in two benches, the upper from 2 feet 8 inches to 2 feet 10 inches thick, and the bottom from 5 to 8 inches thick, with from ½ inch to 2 inches of clay parting between. This bed appears to be remarkably uniform in the southeastern part of Penn Township. The E bed, which is seen in most of the road cuts of the area, lies about 25 to 30 feet higher. Where opened, it has a thickness of from 2 feet to 2 feet 2 inches (Cb21, Cb14). Of the lower beds, the Upper Kittanning or C′ has a thickness of 1 foot 8 inches at Da15. The Lower Kittanning or B bed where measured ranged from 13 inches to 1 foot 8 inches of solid coal. Drilling may reveal some bodies of 2-foot coal in this township (Cb4, Da10, Eb21). The Brookville or A coal probably underlies nearly all of the area. A number of measurements outside the township suggest that drilling may find areas of workable coal at this horizon.

The clays of the region underlying the coals range from 3 feet to 10 feet or more. There is commercial flint clay at the Mercer horizon. The Mercer clay has been extensively mined by the Harbison-Walker Refractories Company on Little Anderson or Cratcher Creek. In the eastern part of the township (Da11 and 12), at Stronach, the flint clay is from 5 to 10 feet thick, overlain by 2 feet of soft clay or black shale, 12 inches of coal, and the massive Homewood sandstone cropping out above.

The district may be summarized as containing (in 1903), or as having contained, small areas of E and D coal of minable thickness confined to the ridge tops, and some areas of undetermined extent of thin coal at the horizons of the C′, B and A coals, some of which will doubtless be mined in time. It contains under the coal beds large amounts of clay of workable thickness, and probably much of it is of good quality. Limestone was seen at one point (Db8) lying 6 feet under the Upper Freeport coal.

In 1938 a new road cut at Db49 gave the following section:

Section east of Bells Landing

		Ft.
Coal bloom ? slumped		
Clay "		
Shale, drab		12
Shale, black or coal bloom	1"-3"	
Shale, drab		10
Coal (A)	10"-14"	1
Clay, drab		4
Coal (A)		½
Clay, sandy, full of root fragments grading into sandstone		8
Hidden		5 to 10
Sandstone, massive (Homewood)		5+

The two benches of the Brookville coal come together a short distance from where this section was measured.

Pike Township and Lumber City

Pike Township, named after General Zebulon Pike, was one of the earliest to be settled. Frederick Haven, of the township, is credited with having built the first ark for transporting coal down the river to sell for about 37½ cents a bushel at Harrisburg and Marietta. Curwensville, located in 1823, was named for John Curwen, a resident of Montgomery County.

The south half of Pike Township centers about Curwensville. The valley of the West Branch of the Susquehanna cuts across the township diagonally with considerable areas of valley land between 1,150 and 1,200 feet above sea level. The uplands, lying between 1,600 and 1,700 feet above sea level, are mostly under cultivation. Anderson and Little Anderson or Cratcher creeks are very narrow and steep-sided. The other streams have more moderate slopes, which are partly under cultivation. The New York Central Railroad follows the valley of West Branch, and the Beech Run Division of the same railroad follows Little Clearfield Creek along the southern boundary of the township. The Buffalo, Rochester and Pittsburgh follows the valley of Anderson Creek to its mouth and down the West Branch. Structurally the Clearfield syncline follows the valley of the West Branch. The syncline brings the Upper Freeport coal down to an elevation of 1,400 feet above sea level in the valleys south of Curwensville. The coal is at 2,050 feet at the north line of the quadrangle and 1,600 feet at the southern edge of the township. As a result, the E coal is above the hilltops north and west of Curwensville. It barely underlies the crests of the hills southwest of Curwensville, but underlies considerable areas in the hills south of the river.

Except for small areas on both sides of Hogback Run, where the crest of the hills catch the D coal, the hills north and west of Curwensville contain only the Lower Kittanning and underlying coal beds. The D coal in the hills facing Hogback Run has the same section as is found in that bed around Hepburnia; that is, an upper bench 2 feet 8 inches to 2 feet 10 inches thick, separated by 2 inches of clay from 8 to 9 inches of coal in a lower bench (Fa9, 13, 14, 15). The B coal in the area north of Curwensville ranges from 18 inches (Fa16) to

3 feet 6 inches or 4 feet (Fa18). In the latter instance the bed had a bony bench 2 to 6 inches thick 6 inches from the bottom. It is likely that there are small areas of solid coal 2 feet thick at this horizon, judging by the coal in adjoining areas. Though not seen, it is believed that the horizon of the Brookville or A bed contains some coal in this area 2 feet or more thick. The Mercer coal is commonly less than 18 inches thick.

Clays of value in this area occur at the B and Mercer horizons. Judging by sections nearby, the clay under the B coal in this area may range from 5 to 15 feet thick and might well become the source of a large clay industry for making brick and tile. The clay at the Mercer horizon has been extensively mined in this area on the upper waters of Hogback Run (Fa3), while the flint clay has a thickness ranging up to 18 feet. In places the clay consists of as much as 11 feet of nodular clay above and 7 feet of block clay below. In other places the thicknesses are reversed. At Ea1, on the east side of Anderson Creek, this bed having a thickness of from 3 feet 6 inches to 10 feet, has been mined by the Curwensville Fire Brick Company. Over the flint clay are 12 inches of shale and 8 inches of coal, the latter being taken down in parts of the mine. West of Anderson Creek this bed has been mined by Harbison and Walker at Ea19 under a cliff of massive sandstone (see Fig. 6A). The clay here is from 5 to 12 feet thick. At Stronach the Mercer bed contains 6 feet of flint clay overlain by 1 to 2 feet of soft clay and 10 inches of coal. In places the hard clay thins out. The floor is sandstone.

The Homewood sandstone is of commercial importance in this area and has been extensively quarried on Roaring Run and just north of the quadrangle. At the Roaring Run quarry the bed consists of 38 feet of almost solid sandstone (see Fig. 11). Fractures and shale films occur rarely. When fresh, this stone has a creamy gray color, except as discolored by iron. Some of the stone is spoiled by iron streaks and by fractures. At the Conemaugh Stone Company's quarry, just north of the quadrangle, the bed is 40 to 50 feet thick, and is coarse-grained, saccharoidal sandstone, locally white. Much stone is wasted because of fractures or iron stains. In that area the stone forms the crest of the plateau, and therefore needs little or no stripping. The sandstone is underlain by clay.

It is of interest that the Homewood sandstone, which forms cliffs and is commercially quarried on Anderson Creek, becomes thin bedded and shaly at Curwensville, and around Clearfield it appears to be replaced by shale containing several coal beds and some flint clay beds. Just at Curwensville the Mercer interval is a shale that has possible value for making brick and tile.

In the area north of the river and south of Little Anderson Creek all of the Allegheny coals are found. The E coal occurs only in the hill crests, and the other coals are found in order below. Openings on the E coal near the west line of the township (Ea18 and Eb10) revealed a thickness of 2 feet 4 inches to 2 feet 6 inches with thin shale partings. The coal has a black shale roof. Thirty feet above is reported 18 inches of coal with a shale roof, and the D bed crops out

32 feet below one of these openings. It is possible that what is here called E and D are split benches of the D bed, and that the bed 30 feet above is the E.

The section on Anderson Creek at Curwensville, starting a short distance up the creek where the Homewood is still fairly massive, is as follows:

Section on Anderson Creek at Curwensville

	Feet
Massive, saccharoidal, quartzose sandstone (Homewood)...	10-8
Coal 2″ Black shale 2″ Coal 17″ } Mercer	1¾
Ferruginous, sandy shale or clay, Mercer fossils (David White) of possible workable quality	30-35
Black sandstone	2
Sandy shale or clay (Mercer fossils, David White)........	30
Dark drab clay and shale (Mercer fossils)	20
Submassive to irregularly bedded sandstone, top shaly....	24
Hidden	10
Massive shale	10

No openings were found on the Lower Freeport or D bed in this part of the township, but judging from sections to the east and west, it is anticipated that the bed will be 3 feet or more thick within its area of outcrop. The Lower Kittanning bed is thin but workable in the hills south of Curwensville, ranging from 2 feet 1 inch to 2 feet 9 inches under a small area (Ea17, Fa40, Fb2, Fb3). A short distance to the west (Eb15) the bed varies from 18 inches to 2 feet in thickness. Near Lumber City (Eb21) it is only 14 inches thick. The Brookville coal was seen at only one point in this area, where it was 2 feet 2 inches thick. At another place it was reported as being 18 inches thick. The Mercer coal in this area is of variable thickness, commonly thin, but locally thickening up to 2 feet 6 inches (Eb26). It is probable that considerable areas of 2-foot coal exist in this area at the horizon of the B, A, and Mercer beds.

The clays of this area are of commercial importance and have been mined at several places. The B clay has been mined at Ea15, where it is from 4 to 6 feet thick. It is used for mixing with the flint clay. The bottom of the bed is sandy. Near Curwensville this bed is 11 feet thick (Fa27) and sections south of the railroad suggest that the same bed may maintain a thickness of from 10 to 20 feet under a considerable area here. Near Lumber City (Eb21) the section below the B coal shows 5 feet of clay, 5 feet of shale, 6 inches of coal, 24 inches of clay, shale, etc. It is likely that the clay under the A coal will be found to be of minable thickness under part or most of this area. The Mercer clay in the Lumber City area has a thickness ranging from 6 to 12 feet. At the Ross Mine (Eb32) there is 2 feet of low-grade clay forming the floor. It is underlain by from 2 to 6 feet of block clay, 8 to 12 inches of dark, shaly clay of low grade, and coal 9 inches thick. At this point the Mercer lies 40 feet below the A bed, 130-150 feet below the B bed, and 250 feet below the C′ bed.

The rest of this township in the quadrangle lies south of the river. In this area the E coal lies from 100 to 200 feet below the tops of the ridges. The Brookville or A coal lies not far above the river at the north and at or below the level of Little Clearfield Creek. Traces of the Brush Creek coal were seen at many points in the hilltops. The E coal, where seen (Fa54 and 56, Fc10), has a thickness of 2 feet to 2 feet 4 inches with a shale roof and clay floor.

In most of this area the D bed is about 3 feet thick with a 1- to 3-inch parting 6 to 12 inches from the bottom. In some of the mines the D bed is overlain by bone coal having a maximum thickness of 5 inches. Above that the roof is shale (Fa44 to Fa46, Fa50, Fa53, Fb10, Fc17, Ec22). It may therefore be judged that this bed is of minable thickness under all or most of the area it underlies. The Upper Kittanning or C′ bed at one point (Ec27) has a thickness of 2 feet 6 inches with ¼-inch parting 6 inches from the top. The roof is shale. The Lower Kittanning or B coal is a solid bed 2 feet or more thick south of Curwensville. Judging by its thickness in nearby areas, this bed is likely to be found to be about 2 feet thick under most of this area. The Brookville or A bed, which is minable east of this area (east of Fc7), appears to be thin (Fc29, Fc7, Fc8).

The underclays of the E, D, B and A beds are all thought to be of possible value in this area, ranging in thickness from 4 feet to nearly 20 feet (Fb8). Outcrops of flint clay in the Lumber City area to the west and along Clearfield Creek to the east suggest that drilling elsewhere may reveal bodies of flint clay at the horizon of the Mercer coal. Along the river, 10 feet of flint clay occurs at Eb35 under massive sandstone, and 2 to 4 feet of flint clay occurs at Eb28 to 30, along with other shales and clays of possible value.

APPENDIX A

Triangulation stations, elevations and bench marks

Triangulation stations. The exact latitude and longitude of the boundaries of the quadrangle have been determined from stations located on some of the most prominent hilltops of the region.

These have been connected by triangulation with astronomical stations at Washington, D. C., Cumberland, Md., Grafton, W. Va., and Pittsburgh, Pa., and the accuracy of the work has been checked by a carefully measured base line.

All surveys for the map of this bulletin are based upon triangulation stations located within the quadrangle or in close proximity thereto. Each station is marked by a stone set firmly in the ground, on the top of which is cemented a tablet marked "U. S. Geological Survey—Pa." The following descriptions will enable engineers to identify them on the ground.

SWOPE, CAMBRIA COUNTY

(Lat. 40° 40′ 47.99″; long. 78° 39′ 04.20″). On a ridge in the central portion of Chest Township, 3 miles by road north-northeast of Patton, in corner of lane 200 yards northwest of residence of Miss Lizzie Swope.

BECK, CLEARFIELD COUNTY

(Lat. 40° 49′ 22.06″; long. 78° 44′ 23.81″). On a cultivated knob in Burnside Township, 2 miles west of New Washington, 5½ miles south of Mahaffey on land owned by Mr. Beck who lives on the southwest side of the knob.

DAVIS, CLEARFIELD COUNTY

(Lat. 40° 59′ 49.58″; long. 78° 32′ 46.88″). On a cultivated flat ridge in timber on its side in Penn Township, 2 miles south of Grampian Station on the southern side thereof, and 15 feet lower than the summit. E. M. Davis, owner, lives ¼ mile south.

NEEPER, CLEARFIELD COUNTY

(Lat. 40° 59′ 49.58″; long. 78° 32′ 88″). On a cultivated flat ridge in Pike Township, 2 miles northwest of Curwensville, owned by R. R. Neeper, who lives on the south side of the ridge.

PATTERSON, CLEARFIELD COUNTY

(Lat. 40° 50′ 45.92″; long. 78° 36′ 59.335″). On cultivated round hill owned by Lyman Patterson, 3 miles east of La Jose, ½ mile south of Marron, and on line between Ferguson and Jordon townships. Station is on fence line where it crosses summit of hill.

SPANGLER, CLEARFIELD COUNTY

(Lat. 40° 45′ 09.40″; long. 78° 30′ 48.17″). On the northern end of cultivated ridge in Beccaria Township, 1½ miles northeast of Coalport, on land owned by Levi Spangler, and about 300 yards east of his residence.

WALLS, CLEARFIELD COUNTY

(Lat. 40° 55′ 20.76″; long. 78° 46′ 25.26″). In a cleared field owned by Andrew Walls in Ball Township, ½ mile northeast of Newtonburg, and 5 miles northwest of Mahaffey, 300 yards west of Mr. Wall's house.

Level lines. The general altitude and configuration of the surface of the quadrangle is shown by means of contour lines which are based upon precise levels run by the United States Geological Survey. During the course of this work numerous bench marks were established here.

Bench marks in the Curwensville Quadrangle

	Feet above sea level (1903 adjustment)
Coalport, crossing at station, top of rail	1414.0
Coalport, .5 mile north of; Cambria and Clearfield Railroad bridge, east end of bridge seat, bronze tablet marked "1378 PITTSBURGH"	1377.565
Irvona, crossing at station; top of rail	1380.0
Berwindale, crossing at station; top of rail	1553.0
Berwindale, .2 mile northwest of; in west end of south abutment of culvert, in corner stone, aluminum tablet marked "1543 PITTSBURGH"	1542.806
La Jose, crossing east of station, top of rail	1315.0
La Jose, between La Jose Junction, railroad bridge No. 35, in northwest coping stone, aluminum tablet marked "1297 PITTSBURGH"	1296.501
Ostend, crossing at; top of rail	1387.0
Mahaffey, New York Central Railroad bridge over Susquehanna River at; in coping stone at east end, south abutment, aluminum tablet marked "1272 PITTSBURGH"	1271.713
Curry Run, railroad bridge over river, in north and south abutment, bronze tablet marked "1222 PITTSBURGH" ...	1221.275
Kermoor, .1 mile west of; railroad bridge No. 44, north end, south abutment of, bronze tablet marked "1356 PITTSBURGH"	1355.957
Olanta, highway bridge over Clearfield Creek at; in northwest abutment of, bronze tablet marked "1296 PITTSBURGH"	1295.256
Curwensville, .2 mile east of; B. R. & P. bridge, in step of abutment of, bronze tablet marked "1143 PITTSBURGH".	1142.668
Grampian, highway bridge over creek at; in southeast cap stone of east abutment, bronze table marked "1535 PITTSBURGH"	1535.225
Westover, northwest corner of Baptist Church, top corner stone, the foundation of in west face, bronze tablet marked "1368 PITTSBURGH"	1368.114

APPENDIX B

Coal Reserves

Explanation of the table. In the following table is shown the approximate acreage of each township or that part of it included within this quadrangle. Under each township are given each of the principal coal beds or horizons and the area within that township (within the quadrangle) underlain by the coal. These areas were determined by placing cross section paper over the map showing the coal outcrops. The cross section paper was divided into 64 squares to the square inch, each square being equal to 10 acres for a horizontal scale of the map of one mile equals one inch. In counting, the squares were counted if more than half underlain by the coal bed and rejected if less than half underlain. This method is as accurate as the accuracy of the outcrop lines would warrant.

Then all of the bed measurements on a given bed in a township were brought together, including not only the sections given in the drawn figures, but also all of those from drill records as well. These measurements are then divided into three groups; those over 2 feet, those between 1 and 2 feet, and those under 1 foot in thickness. In recording these thicknesses, the net thickness only was used; that is, the thickness left after rejecting any minor bench separated from the main bench by a parting of greater thickness than that of the coal bench; or if the parting be thinner than the minor coal bench, only the difference in the thickness of the minor bench and the parting was added to the thickness of the major bench. The purpose of such procedure is, if possible, to use such a measurement as would, if it represented solid coal, be about equivalent to the split up bed. A couple of examples will illustrate the method. For example, a coal section reads: coal, 6 inches; shale, 14 inches; coal, 26 inches, a total of 46 inches. Obviously this is not a 46-inch bed, for there are only 32 inches of coal in it. Nor is it equal to a solid 32-inch bed, for it is doubtful if the mining of the 6-inch bench would pay for moving the 14 inches of shale. According to the rule, the 6-inch bench is thrown out in computing the thickness of the bed. Another section reads: coal, 6 inches; clay, 2 inches; coal, 10 inches; bone, 9 inches; coal, 16 inches. Starting with the 16-inch bench as the main bench, it will be noted that the two minor benches are each thicker than the underlying parting, making together 16 inches against 11 inches for the partings. The two minor benches are therefore computed to add 5 inches to the equivalent thickness of the bed, giving a total value of 21 inches. In other words, this bed 43 inches thick is rated as equivalent to a 21-inch bed for mining purposes.

To return to the three groups of sections. First, the average was obtained of all those over 2 feet in thickness, and this average, reduced to the next lower quarter of a foot, is given in the column under the head of: "coal over 2 feet thick." An average thickness of 18 inches was assumed for the coals between 1 and 2 feet, unless a large number of sections indicated a lower or higher average. Then an estimate was made of the proportion of the area underlain by coal over 2 feet thick, by coal between 1 and 2 feet, and by coal under 1 foot or lacking

Coal reserves in Curwensville quadrangle

Townships, coal beds	Acreage	Coal between 1 and 2 feet thick				Coal more than 2 feet thick				Net tonnage
		Average thickness		Acreage	Total tonnage	Average thickness		Acreage	Total tonnage	
		Ft.	in.			Ft.	in.			
CLEARFIELD COUNTY:										
Brady Township:	630									
E coal	310	1	6	100	270,000	3		200	1,180,000	600,000
D coal	400	1	6	50	135,000	2	6	350	1,565,000	875,000
C′ coal	440	1	3	300	675,000	2	6	100	450,000	250,000
C coal	480	1	3	300	675,000	2	6	100	450,000	250,000
B coal	520	1	6	200	540,000	2	3	300	1,115,000	675,000
A coal	600	1	3	200	225,000	2		100	360,000	200,000
Totals					2,520,000				5,120,000	2,850,000
Bell Township	15,180									
E coal	3,490	1	6	1,000	2,700,000	3		2,000	10,800,000	6,000,000
D coal	5,410	1	6	1,000	2,700,000	2	6	4,000	18,000,000	10,000,000
C′ coal	7,930	1	6	3,000	8,100,000	2	6	2,000	9,000,000	5,000,000
C coal	10,450	1	6	6,000	16,200,000	2	6	2,000	9,000,000	5,000,000
B coal	12,980	1	6	4,000	10,800,000	2	3	8,000	32,400,000	18,000,000
A coal	14,530	1	6	5,000	13,500,000	3	9	3,000	20,250,000	11,500,000
Totals					54,000,000				99,450,000	55,500,000
Penn Township	18,480									
E coal	3,450	1	6	1,500	4,150,000	2	6	1,500	875,000	375,000
D coal	5,580	1	6	500	1,350,000	3	3	5,000	29,250,000	13,250,000
C′ coal	9,370	1	6	5,000	13,500,000	2	0	2,000	7,200,000	4,000,000
C coal	13,160	1	6	7,000	18,900,000	2	0	3,000	10,800,000	6,000,000
B coal	16,960	1	6	10,000	27,000,000	2	6	5,000	22,500,000	12,500,000
A coal	17,840	1	6	7,000	18,900,000	2	6	5,000	22,500,000	12,500,000
Totals					83,800,000				93,125,000	48,625,000
Burnside Township	12,380									
E coal	10,950	1	6	5,000	13,500,000	2	9	3,000	14,850,000	8,250,000
D coal	11,830	1	6	5,000	13,500,000	2	6	4,000	18,000,000	10,000,000
C′ coal	12,300	1	6	6,000	16,200,000	2	3	4,000	16,200,000	9,000,000
C coal	12,380	1	6	6,000	16,200,000	2	3	8,000	28,350,000	18,000,000
B coal	12,380	1	6	4,000	10,800,000	2		2,000	7,200,000	4,000,000
A coal	12,380	1	6	6,000	16,200,000					
Totals					86,400,000				84,600,000	49,250,000

Coal reserves in Curwensville quadrangle—Continued

Townships, coal beds	Acreage	Coal between 1 and 2 feet thick				Coal more than 2 feet thick				Net tonnage
		Average thickness		Acreage	Total tonnage	Average thickness		Acreage	Total tonnage	
		Ft.	in.			Ft.	in.			
CLEARFIELD COUNTY—Continued:										
Chest Township	22,830									
E coal	9,310	1	6	4,000	10,800,000	2	6	2,000	9,000,000	5,000,000
D coal	12,500	1	6	5,000	13,500,000	2	9	3,000	14,850,000	8,250,000
C′ coal	15,250	1	6	7,000	18,900,000	2	6	5,000	22,500,000	12,500,000
C coal	18,000	1	6	10,000	27,000,000	2	3	6,000	24,300,000	13,500,000
B coal	20,770	1	6	15,000	40,500,000	2	0	3,000	10,800,000	6,000,000
A coal	21,570	1	6	10,000	27,000,000	2		1,000	3,600,000	2,000,000
Totals					137,700,000				85,050,000	47,250,000
Ferguson Township	13,080									
E coal	6,670	1	6	2,000	5,400,000	2	3	4,000	14,175,000	9,000,000
D coal	7,580	1	6	3,000	8,100,000	2	6	4,000	18,000,000	10,000,000
C′ coal	8,990	1	6	4,000	10,800,000	2	6	2,000	9,000,000	5,000,000
C coal	10,400	1	6	6,000	16,200,000	2	0	2,000	7,200,000	4,000,000
B coal	11,820	1	6	8,000	21,600,000	2	0	2,000	7,200,000	4,000,000
A coal	12,680	1	6	9,000	24,300,000	2	0	1,000	3,600,000	2,000,000
Totals					86,400,000				59,175,000	34,000,000
Bloom Township	2,600									
E coal	180					2	9	180	891,000	495,000
D coal	370	1	6	70	189,000	2	6	300	1,350,000	750,000
C′ coal	800	1	3	300	675,000	2	6	300	1,350,000	750,000
C coal	1,230	1	3	600	1,350,000	2	6	300	1,350,000	750,000
B coal	1,670	1	6	800	2,160,000	2	3	800	3,240,000	1,700,000
A coal	2,090	1	3	1,000	1,125,000	2		400	1,440,000	800,000
Totals					5,499,000				9,621,000	5,245,000
Greenwood Township	14,420									
E coal	3,740	1	6	1,000	2,700,000	2	3	2,500	10,625,000	5,625,000
D coal	5,400	1	6	2,000	5,400,000	2	9	3,000	14,850,000	8,250,000
C′ coal	7,190	1	6	4,000	10,800,000	2	6	1,000	4,500,000	2,500,000
C coal	8,980	1	6	4,000	10,800,000	2	3	1,000	4,050,000	2,250,000
B coal	10,790	1	6	8,000	21,600,000	2		2,000	7,200,000	4,000,000
A coal	14,000	1	6	9,000	24,300,000	2		1,000	3,600,000	2,000,000
Totals					75,600,000				44,825,000	24,625,000

Coal reserves in Curwensville quadrangle—Continued

Townships, coal beds	Acreage	Coal between 1 and 2 feet thick				Coal more than 2 feet thick				Net tonnage
		Average thickness		Acreage	Total tonnage	Average thickness		Acreage	Total tonnage	
		Ft.	in.			Ft.	in.			
CLEARFIELD COUNTY—Continued:										
Pike Township	16,110									
E coal	2,070	1	6	500	1,350,000	2	3	1,500	6,075,000	3,375,000
D coal	3,300	1	6	500	1,350,000	3	3	2,500	14,625,000	8,125,000
C′ coal	4,680	1	6	3,000	8,100,000	2	6	500	2,250,000	1,250,000
C coal	6,060	1	6	3,000	8,100,000	2	6	500	2,250,000	1,250,000
B coal	7,460	1	6	4,000	10,800,000	2	3	3,000	12,150,000	6,750,000
A coal	11,910	1	6	3,000	8,100,000	2		3,000	10,800,000	6,000,000
Totals					37,800,000				48,150,000	26,750,000
Jordan Township	15,360									
E coal	8,160	1	6	2,000	5,400,000	2 4	6 0	3,000 3,000	13,500,000 21,600,000	7,500,000 12,000,000
D coal	10,410	1	6	3,000	8,100,000	2	9	7,000	34,650,000	19,250,000
C′ coal	11,800	1	6	4,000	10,800,000	2 2	0 3	3,000 4,000	10,800,000 16,200,000	6,000,000 9,000,000
C coal	13,200	1	6	5,000	13,500,000	3	0	2,000	10,800,000	6,000,000
B coal	14,630	1	6	4,000	10,800,000	2	9	10,000	49,500,000	27,500,000
A coal	15,360	1	6	6,000	16,200,000	2		4,000	14,400,000	8,000,000
Totals					64,800,000				171,450,000	94,750,000
Knox Township	4,500									
E coal	1,260					2	9	1,000	4,950,000	2,750,000
D coal	2,270	1	6	250	810,000	3	3	2,000	11,700,000	6,500,000
C′ coal	2,660	1	6	1,500	4,150,000	2		500	1,800,000	1,000,000
C coal	3,050	1	6	2,000	5,400,000	2	6	500	2,250,000	1,250,000
B coal	3,450	1	6	1,000	2,700,000	2	3	2,000	8,100,000	4,500,000
A coal	4,320	1	6	2,000	5,400,000	2		1,000	3,600,000	2,000,000
Totals					18,460,000				32,400,000	18,000,000
Bigler Township	180									
E coal	30					2	9	25	±120,000	±70,000
D coal	40					3	3	40	±230,000	±130,000
C′ coal	70	1	6	50	±130,000	2		20	±70,000	±40,000
C coal	100	1	6	50	±130,000	2	6	25	±110,000	±60,000
B coal	130	1	6	25	±60,000	2	3	100	±400,000	±230,000
A coal	180	1	6	100	270,000	2		20	±70,000	±40,000
Totals					590,000				980,000	470,000

Coal reserves in Curwensville quadrangle—Continued

Townships, coal beds	Acreage	Coal between 1 and 2 feet thick			Coal more than 2 feet thick			Net tonnage
		Average thickness	Acreage	Total tonnage	Average thickness	Acreage	Total tonnage	
		Ft. in.			Ft. in.			
CLEARFIELD COUNTY—Continued:								
Beccaria Township	10,630							
E coal	1,960				2 3	500	6,075,000	
D coal	2,930	1 6	1,000	2,700,000	2 9	1,500	7,425,000	4,175,000
C′ coal	4,640	1 6	2,000	5,400,000	2 6	1,000	4,500,000	2,500,000
C coal	6,350	1 6	2,000	5,400,000	2 6	1,000	4,500,000	2,500,000
B coal	8,080	1 6	3,000	8,100,000	3 6	4,000	25,200,000	14,000,000
A coal	9,690	1 6	4,000	10,800,000	2	1,000	3,600,000	2,000,000
Totals				32,400,000			51,300,000	25,175,000

SUMMARY

	Tons	Percent
Estimated recoverable coal between 2 feet and 3 feet (future reserve)	354,395,000	82
Estimated coal between 3 feet and 4 feet	66,105,000	15
Estimated coal over 4 feet	12,000,000	3
Total estimated recoverable coal	432,490,000	100

This does not allow for coal mined out, which must be subtracted to arrive at reserve still in the ground.

entirely. These figures are quite arbitrary and doubtless with the same data would hardly be estimated exactly alike by any two persons, or even by the same person at two different times. Where the data were mainly in the nature of drill records, the proportion has been determined by the proportion of measurements in the three groups. For example: in a particular case a certain bed in one of the townships underlies 5,400 acres. Of the 18 measurements on that bed, 4 were of less than 1 foot thickness; 8 were between 1 and 2 feet in thickness; 6 over 2 feet. Accordingly the acreage was divided proportionally into: 1,800 acres as underlain by coal over 2 feet thick; 2,400 acres as underlain by coal between 1 and 2 feet thick; and 1,200 as containing no coal at that horizon or as underlain by coal less than 1 foot thick. In general, the data were principally of measured sections, partly from commercial mines, partly from neighborhood openings. Experience has shown that these measurements average as a rule above the average of the district, first for the reason that commercial mines are usually located only after a study of the field and in the areas of the thickest and best coal. In like manner, openings made by farmers are kept open only if the coal is of fair thickness. Openings made where the coal proves to be thin are allowed to fall shut again and are soon forgotten. For this reason, in estimating the area assumed to be underlain by the three different thicknesses, a general knowledge of the character of the bed is taken into considration as well as the local data. The coal over 2 feet thick is treated as available; that between 1 and 2 feet thick as in reserve; that below 1 foot as valueless. The township is made the unit of area in the belief that the most frequent demand for such figures will be by counties and townships.

APPENDIX C

List of Coal Mines

The following list of coal mines is made up primarily from those visited and examined in 1903; secondly, from visits made subsequent to 1903 by the writer, by R. W. Stone and by F. T. Moyer. The third source of information was schedules filled out by the State Mine Inspectors under an agreement entered into by the Survey and the State Department of Mines by which the State Inspectors carried with them printed schedules and as opportunity offered filled those schedules out. As a rule, the information thus obtained failed to locate the mines accurately and often failed to indicate whether a mine was a newly opened mine or a mine formerly operated under some other name, or a mine at the same locality as a preceding mine but operating on another bed. An effort was made to check this information against such information as we had, but the possibility of error through the lack just cited must be recognized and allowed for. It is known that in some instances the same mine has been operated under different names by different companies. As noted in the list, some of the mines are not located with reference to the map. For others the section of the coal as given on the schedule is shown on one of the plates, but without a map location. Doubtless, at this time most of these mines have been worked out and abandoned. As a matter of fact, a number of them had been abandoned when this survey was made in 1903, but where mines were still open so that sections could be obtained, they appear on the list with their section.

List of coal mines

Map	Reference Figure Number	Name of mines	Name of companies	Bed	Thickness in inches	Elevation in feet A. T.
Fb43	19:171	Alden 2	Denro C. M. Co.	D	33	1,410
Ce7	21:133	Ames 1 & 2	Pine Ridge C. Co. & others	C′	36	1,475
Ce20		Ames 3	" " " " " "	D	60	1,505
Dh22	15:147	Apex 1	Ellery C. M. Co.	D	31	1,605
Ca13	17:45	Belfast	Belfast C. Co.	D	52	1,700
		Belinore	Belinore C. Co.			
Da21	15:146	Bell Run	Bell Run C. Co.	E	34	
Ce1	25:46	Bell Run	" " " "	A	36	
De16	18:103	Berwindale	Andrew Kenedy	D	34	1,580
De16	21:183	Berwindale	Berwindale C. Co. & others	C′	36	1,524
Ea15	23:7	Bickford	Bickford Fire Brick Co.	B	24	
Ef1	23:28	Black Elk	Victor Collieries Co.	B	36	1,500
?		Blain Run 10	Blain Run C. Co.			
Fh39	19:170	Bloomington 19A	Peale, Peacock & Kerr	D	36	1,385
Fb44	19:170	" 20A	" " " "	D	36	1,385
Fe25	19:177	Blue Run	Blue Run C. Co.	D	42	1,600
Ce23	20:181	Bofast	Bofast Coal Co.	C′	34	
Db47	19:165	Bowers	Chas. Bowers & Co.	D	36	
Fa33	23:10	"	" " " "	B	25	
Fe10	21:122	Buck Run	Buck Run C. M. Co.	C′	31	
Fa53	18:76	Caldwell 1	Clearfield Collieries Co.	D	38	1,319
Fe48	18:81	Caldwell 2	" " "	D	36	1,655
Ff?	22:84	Cambria Smokeless	Imperial C. Corp.	B	46	
Ff(s)		" "	Cambria Smokeless C. Co.			
Fd16	18:89	Carnwath 1	Carnwath C. Co.	D	37	
Fd17	18:83	" 2	" " "	D	37	1,660
Fd23	25:57b	" 3	" " "	A	43	1,500
Fd21	19:175	" 4	" " "	D	36	1,671
Fd10	19:173	Central Moshannon	Central Moshannon C. Co.	D	50	
De8	18:101	Cheston	Gresner & Co.	D	38	1,570
		Chestnut Ridge	Chestnut Ridge C. M. Co.	C′	52	
		Clearfield Coll.	W. M. Thomson			
		Coaldale 11	Coaldale M. Co.			
		" 14	Pinkinton & Ellery			
De22?	19:163	" 15	Ellery C. M. Co.	D	35	1,700
Be16	21:130	Continental	Superior C. M. Co.	C	25	
Db45	15:149	Curwensville	Curwensville C. Co.	E	23	
Db46	19:166	"	" " "	D	17	
Ad1		Deer Run	Deer Run C. M. Co.			
Ce22	21:180	Elton Colliery	Thomas-Lee C. M. Co.	C′	37	1,416
Fe1		Falcon 1 & 2	See McCartney 1 & 2	D		
		" 3	W. F. Jacoby	E	32	

List of coal mines Continued

Reference		Name of mines	Name of companies	Bed	Thickness in inches	Elevation in feet A. T.
Map	Figure Number					
		Fordham	Fordham C. M. Co.			
Ed21	18:86	Gazzam 1	Clearfield Bit. C. Corp.	D	37	1,371
Ed29		" 2	" " " "	D		1,550
Ed30		" 3	" " " "	D		1,545
Dd7	18:88	" 4	" " " "	D		1,525
Ed19	18:87	" 5	" " " "	D	30	1,548
Ef32		Glen Brook 2	Glen Brook Collieries Co.	B	36	1,460
Fe36	19:178	Glen Hope	Glen Hope C. M. Co.	C	28	1,500
Cb23	19:162	Good 22A	Good Clay & Coal Co.	D	36	1,400
Ec22	19:167	" 23A	" " " " "	D	29	
Ec26		"	" " " " "	E	26	
		Grampian 1 & 2	R. C. Fishburn & Co.			
Db12	17:55	Harbison & Walker	Harbison & Walker Ref. Co.	D	35	
Ca14	15:143	H. K. Colliery 1	H. K. Colliery Co.	E	28	1,700
	19:161	" " " 2	C. B. Danoier	D	36	1,700
Fa63	17:50	Holden 1		D	44	
Fa?	21:184	Holden 3	Crescent Ref. Co.	C′	23	1,289
Ad16	19:157	Howard	Woodland C. M. Co. & others	D	36	1,475
Ff29		Irvona 1	Irvona C. & C. Co.	B		1,461
		Irvona 2	" " " " "	B		
Ff30	22:30	" 3	(Same opening as 10)	B	32	1,459
Ff31		" 4		B	32	
Ff15		" 5		B	32	1,465
Ff32		" 6		B	34	1,463
		" 7		B		
		" 8		B		
Ff16	23:36	" 9		B	54	
Ff28	22:79	" 10		B	60	1,465
		Irwin	Dunsmore C. Co.			
De15	20:182	Lakeside	Lakeside C. Co.	C′	38	1,518
Bc1	18:65	Lee Run 1	Clearfield & Cambria C. Co.	D	36	1,479
Bd2	17:64	" " 2	" " " " "	D	36	1,457
Dd4	18:65	" " 3	" " " " "	D	36	1,505
		Lindsey 8	Lindsey C. M. Co.			
		Lochie 1	Glen Hope-Moshannon C. Co.	D	42	1,500
Fe1	18:92	McCartney 1	Quinn-Linler C. Co.	D	31	1,730
Fe38		" 3	" " " "	E	48	1,810
Ad6		Mahaffey	Mahaffey C. M. Co.	D	34	
Ac13	19:158	M. & M.	M. & M. C. Co.	D	30	
		Midvale 1 & 2	W. A. Gould & Bro. & others	D	54	1,750
Fd12	18:90	" 3	" " " " " (new, 1904)	D	54	1,750
Fd11	19:174	" 4	" " " " "	D	46	1,760
Fd12	15:151	" 4	" " " " "	E	66	1,790

List of coal mines—Continued

Reference		Name of mines	Name of companies	Bed	Thickness in inches	Elevation in feet A. T.
Map	Figure Number					
Ff21		National 1	Phila. C. & C. Co.	B	69	
		" 2	" " " " "	B		
Ff16		" 5	" " " " "	B	48	1,074
Fa57	22:78	Norris	Norris & Co.	B	23	
Ef	23:82	Paramount	Paramount C. M. Co.	B	60	1,495
Da3	17:47	Penn 2	Clearfield & Grampian C. Co.	D	67	
Ca14	17:46	" 3	Or Mitchel Burns, est.			
		" 3A	Or Burns Bros.	B	32	
	13:144	" 3B	" "	E	28	1,697
Da20	19:160	" 4	" "	D	48	1,700
Ca16		" 5	Grampian C. M. Co.	B	56	
		" 9	" " " "	B	48	
Fe8	18:93	Pennsylvania 24	Penna. C. & C. Co.-Lamborn C. Co.	D	57	1,690
Ef21	23:31	" 25	" " " " "	B		
Fe3	18:94	Porter Run 1	Hilling & Morgan	D	63	
Da7	16:8	Priscilla 2	Priscilla C. M. Co.	E	35	
Ac12	16:142	Mann Coal Co.	Mann	E	32	
Da7		Priscilla 3	Priscilla C. M. Co.	D	18	
		" 6	" " " "	C′	30	
Fa51	19:169	Pyramid	Pyramid C. M. Co.	D	40	1,190
		Rabold 2	Burns Bros.			
Be2?	19:159	Roberta	Roberta C. Co.			
Fb40	19:172	Rowles Sta. 1	N. Amer. Refractories Co.	D	42	1,340
Fb41	15:150	" " 2	" " " "	E	27	1,390
		Shawnee 1	Shawnee C. M. Co.			
Ad5	16:18?	Snyder	Mahaffey C. M. Co.	E	35	
Ec37	22:86	Sunshine 1	B. & B. Coal Co.	C	30	
		Superior 1	Coalport C. Co.			
Ff35	22:81	Swank 2	Hiram Swank's Sons	B	30	
Ef35		Swank 9	" " "	E	40	
		Vega	Beulah Shaft C. Co.			
Fc	23:39a	Wallace 2	Shawnee C. M. Co.			
Bf7	21:118	Welshdale 4	Clearfield & Cambria C. Co.	C′	39	
		Whitmer 1				
Ef27		" 2	Phila. C. & C. Co.	B		
Ef24	23:32	" 3	Whitmer C. & C. Co.	B	60	
		Wiley	Wiley C. Co.			
Ce1	21:132	Wilson Run	Mosher & Jose	C	31	
Ef18	23:83	Wister 3	Turley C. M. Co.	B	40	1,550
Fe37?	15:153	Witherow 1	Lamborn C. Co., Pa. C. & C. Co.	E	48	1,808
Fe8	18:101	" 2	" " " " " " " "	D	40	1,732

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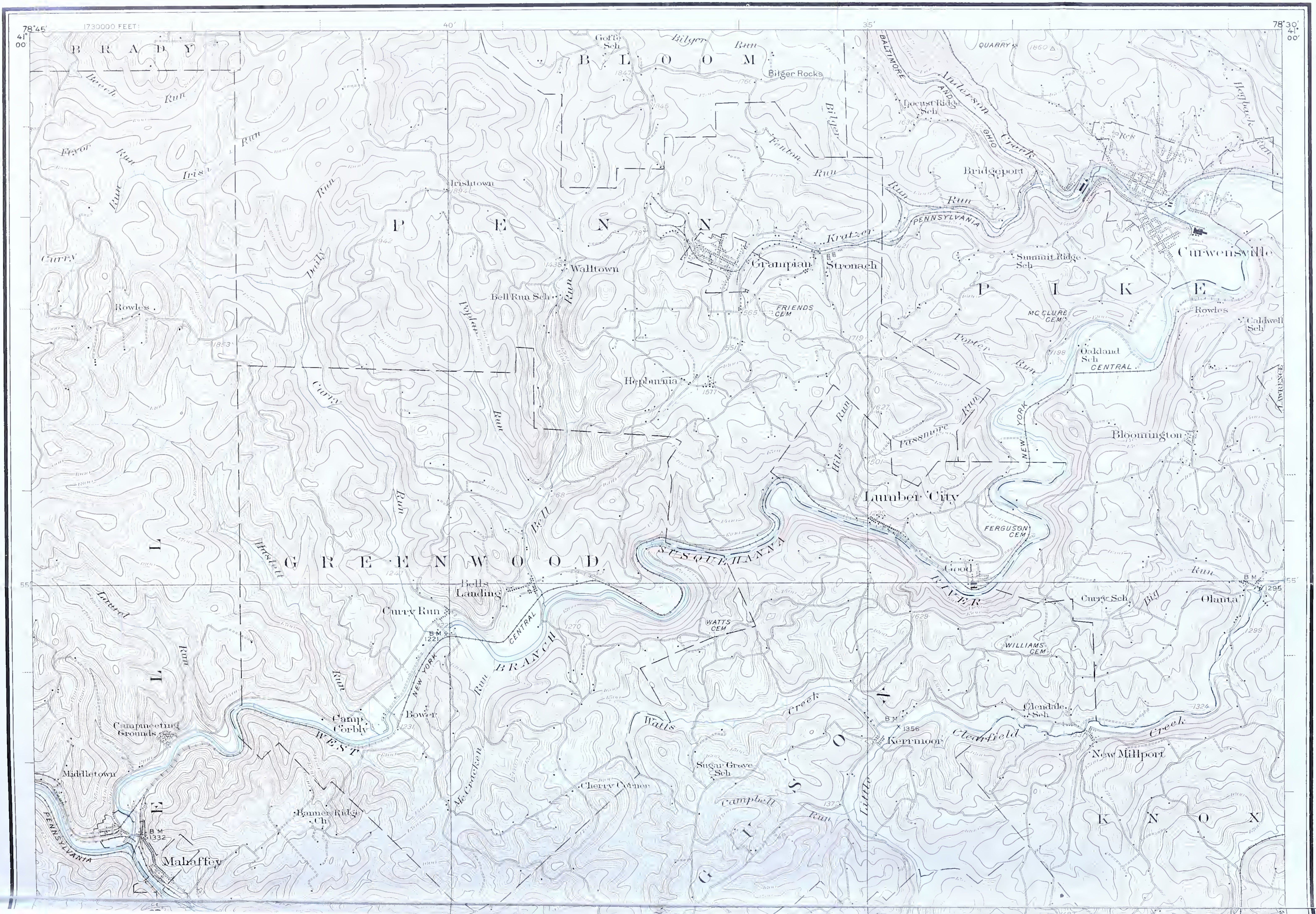

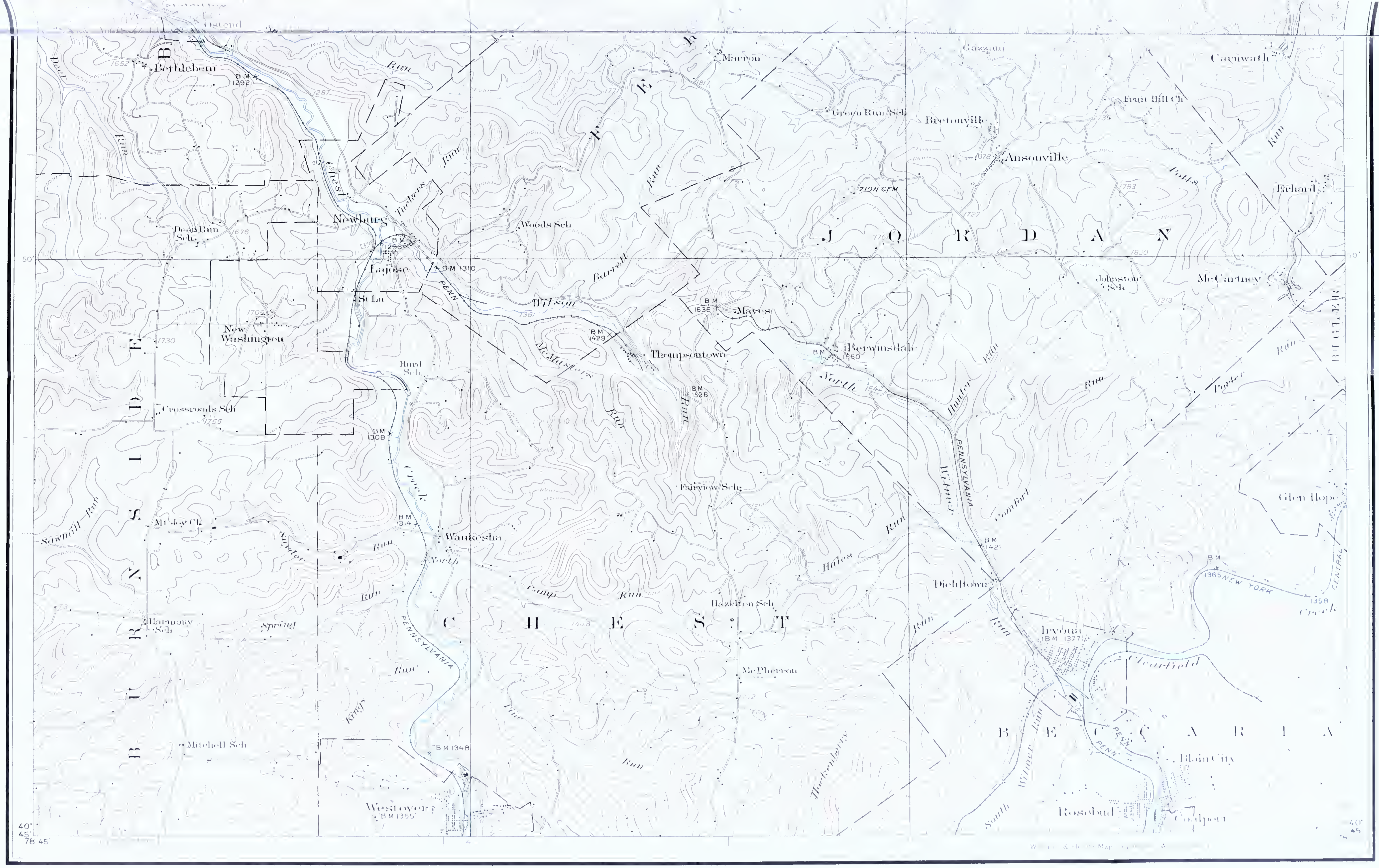

Base from U. S. Geological Survey topographic
map of Curwensville quadrangle, Pennsylvania.
Surveyed in cooperation with the
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Revision by R. F. Hamke in 1939.

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Showing Topography

Scale $\frac{1}{62500}$

Contour interval 20 feet

Datum is mean sea level

1939

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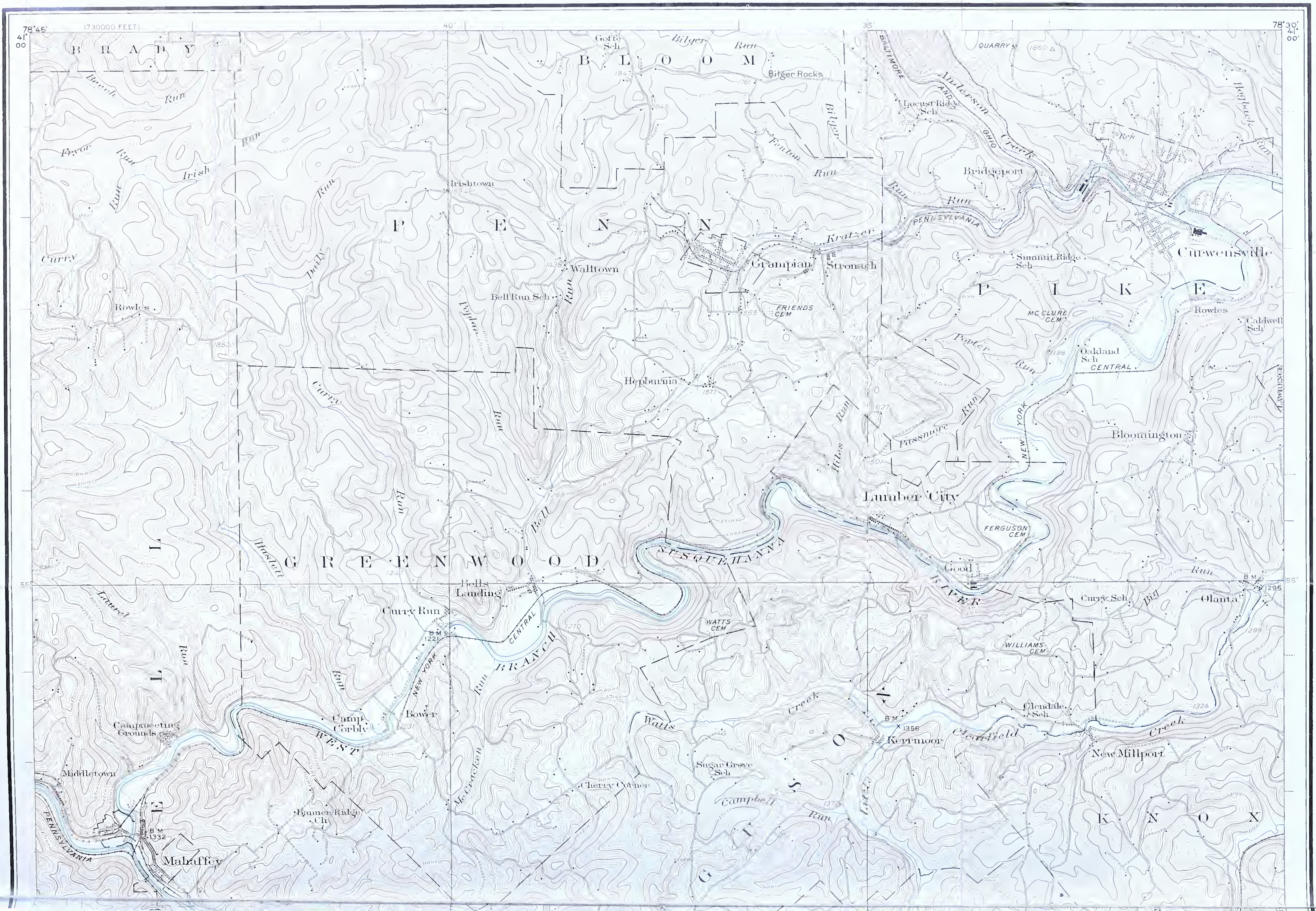

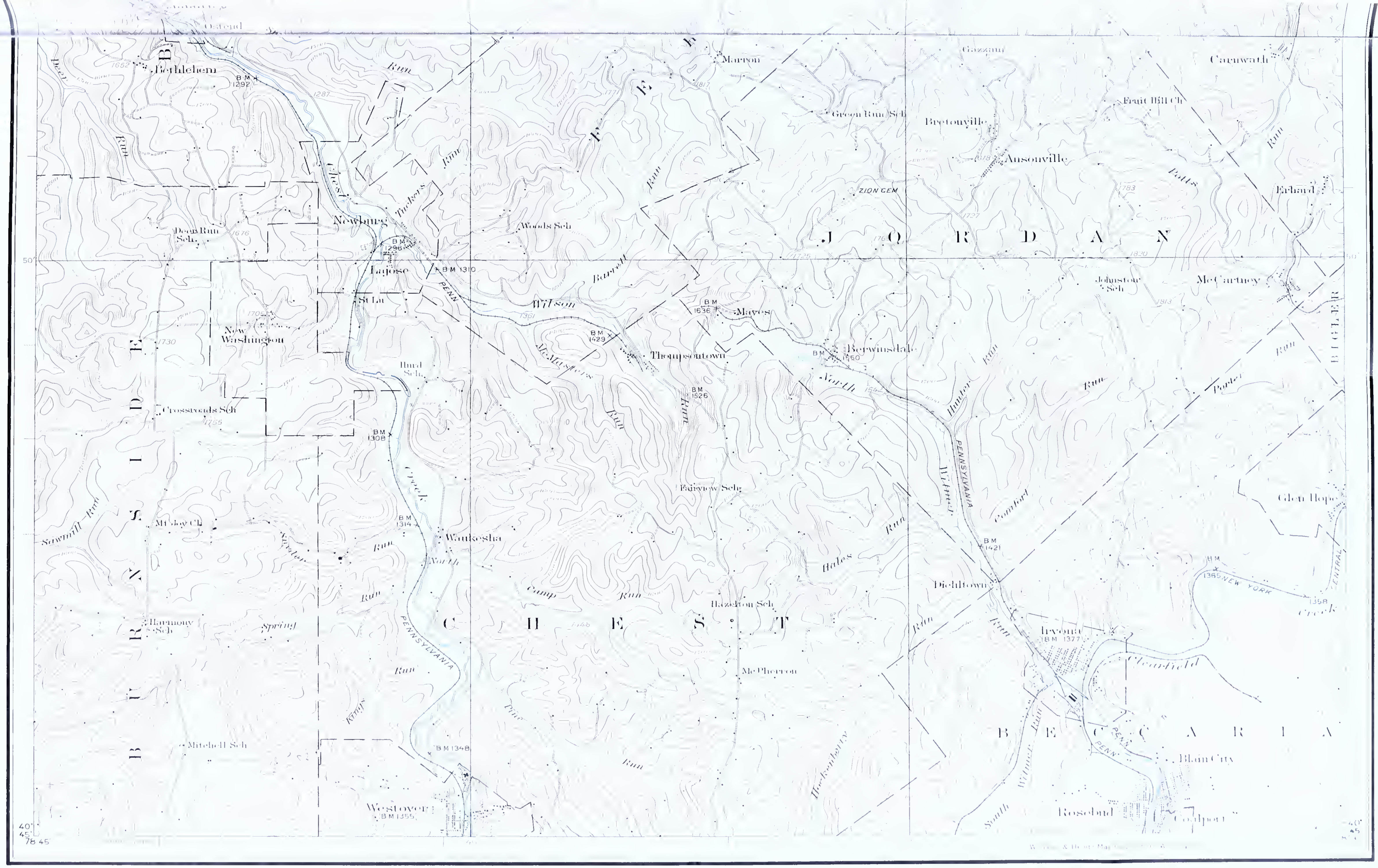

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Showing Topography

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet

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1939

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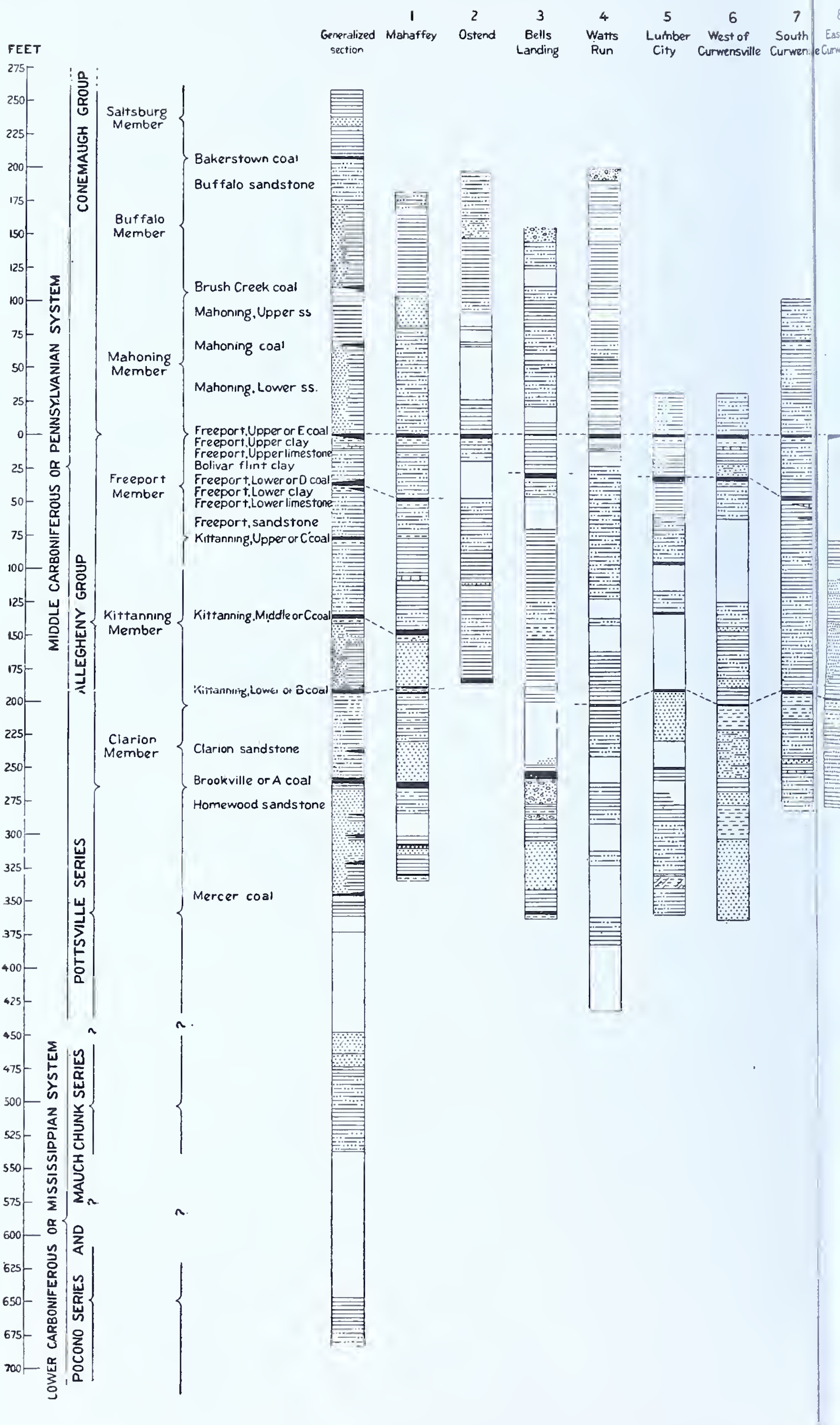

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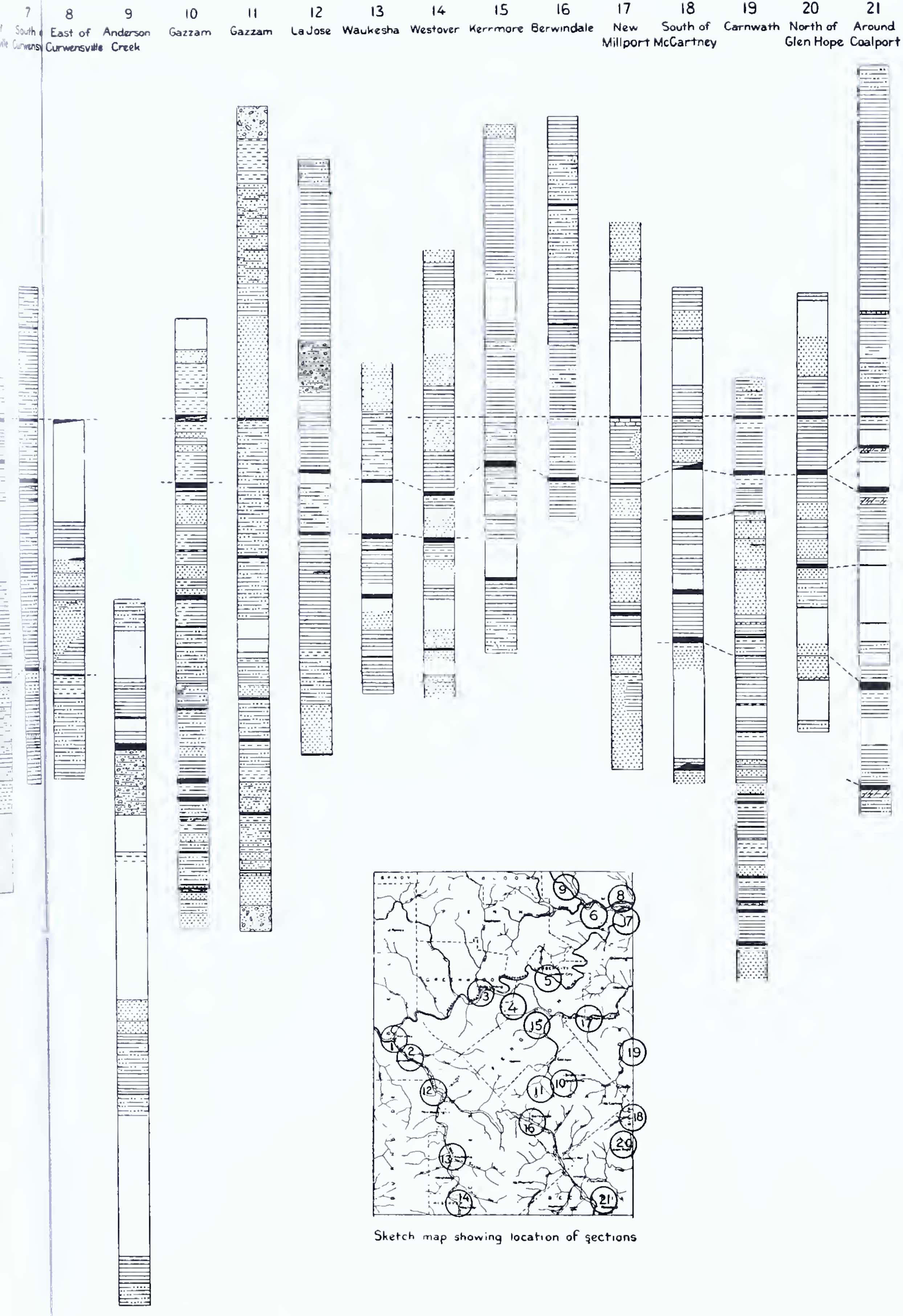

Sketch map showing location of sections

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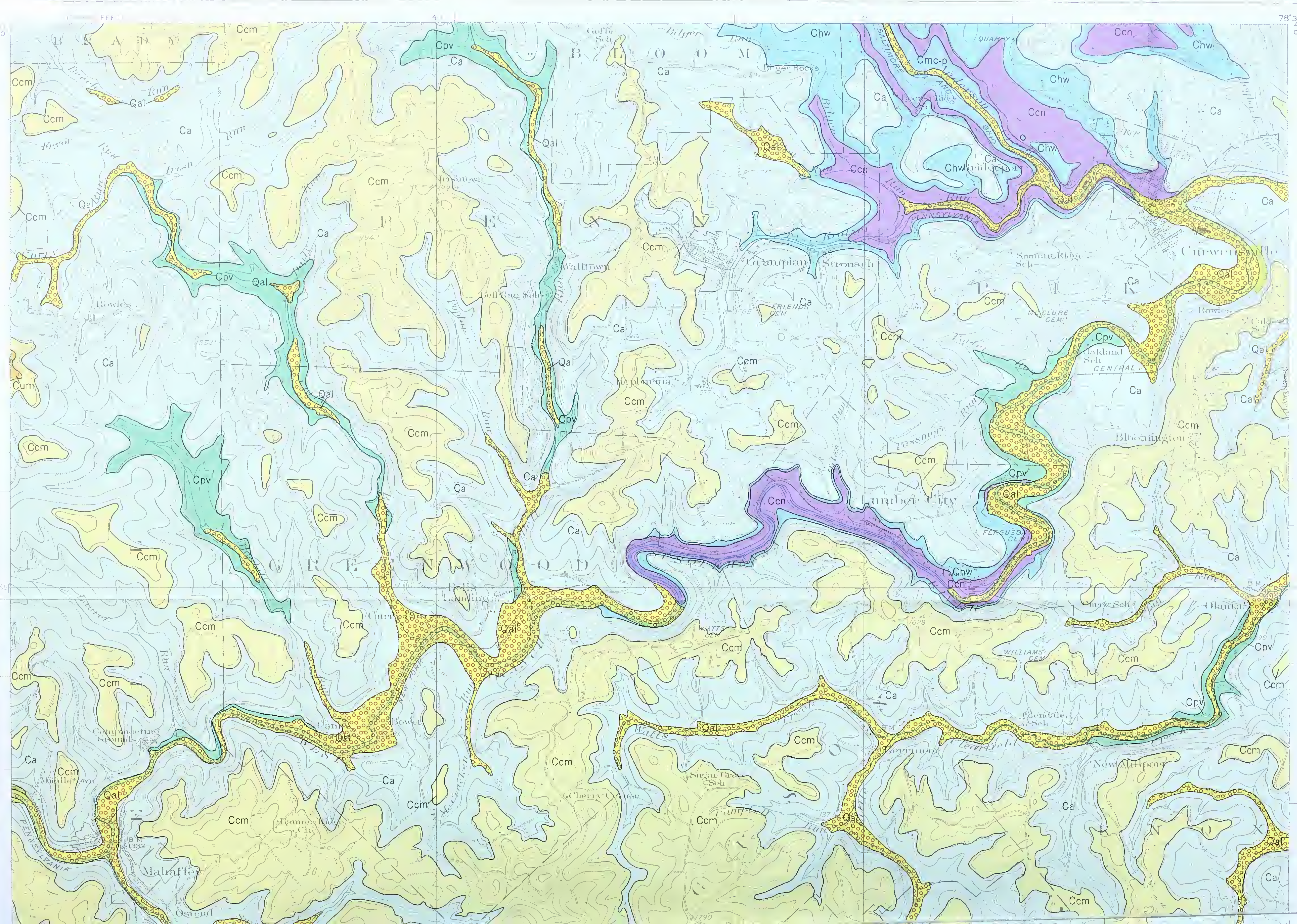
ATLAS OF PENNSYLVANIA
SHEET 75, CURWENSVILLE AREA, PLATE III



EXPLANATION

SEDIMENTARY ROCKS

Qal

Alluvium
(in flood plains of present streams)

Ccm
Cum

Conemaugh group
(shale, thin limestone, sandstone, some red shale, thin coal beds locally workable, and coarse thick-bedded sandstone comprising the Upper Mahoning member, Cum)

Ca
Ccl

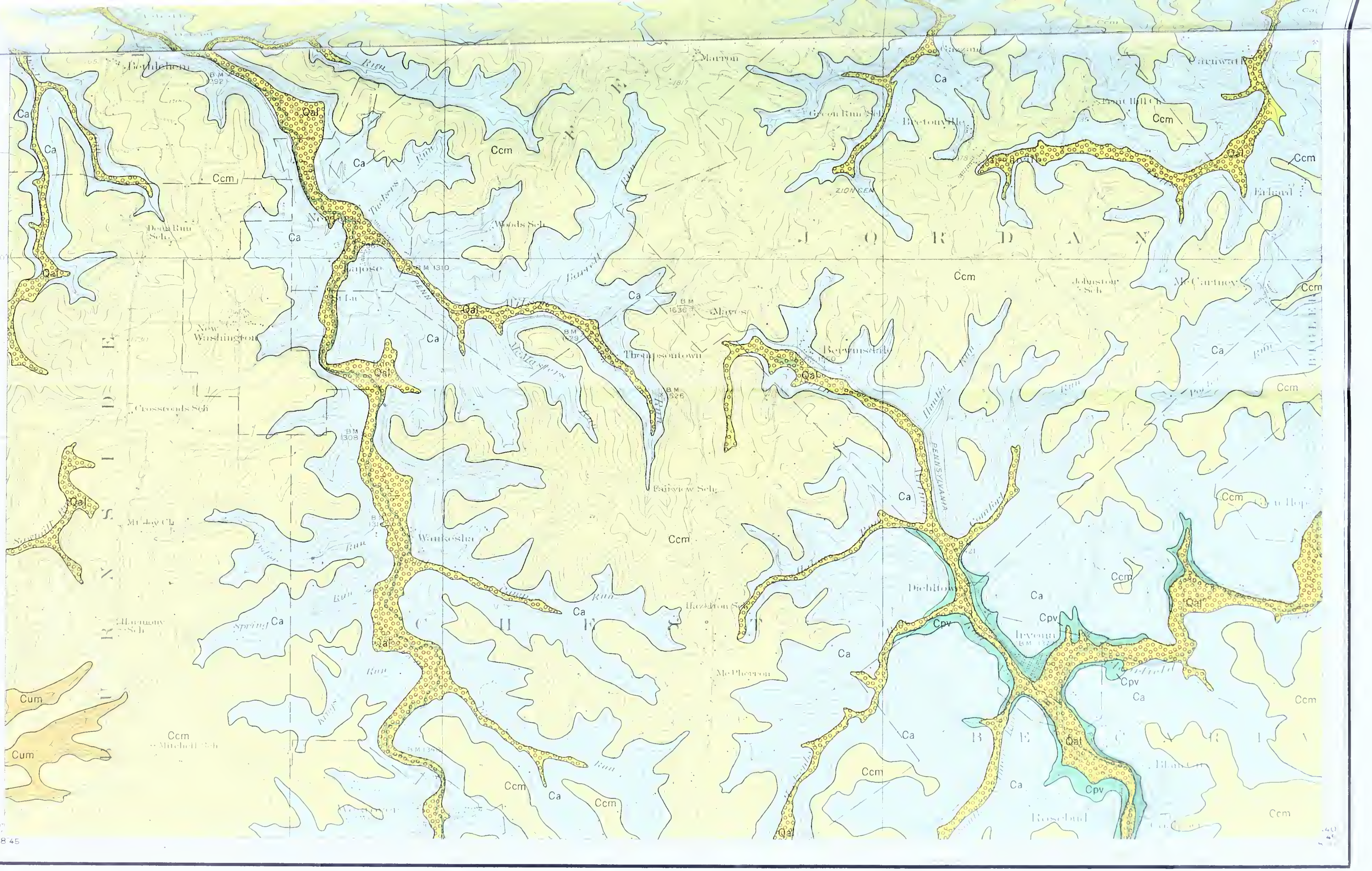
Allegheny group
(chiefly light and dark gray clay shale with variable beds of coarse gray sandstone and several valuable coal beds. Upper Freeport coal on top, Brookville coal at base containing Clarion, Ccl, and other sandstone members)

Cpv | Chw | Ccn

Pottsville series
(thick-bedded sandstone with shale in middle carrying locally the Mercer coals and clay. Cpv undivided Pottsville: Chw Homewood sandstone with Mercer coal and clay at base: Ccn Connoquenessing sandstone and shale)

Cmc-p

Mauch Chunk and Pocono series
(sandstones and shales, the latter locally red or green)



Base from U. S. Geological Survey topographic map of Curwensville quadrangle, Pennsylvania.
Surveyed in cooperation with the State of Pennsylvania in 1902.
Revision by R. F. Hamke in 1939.

MAP OF THE CURWENSVILLE QUADRANGLE, PENNSYLVANIA

Showing Areal Geology

Geology by Geo. H. Ashley, and F. G. Clapp, 1903 for the U. S. Geological Survey, in cooperation with the Topographic and Geologic Survey Commission of Pennsylvania.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet

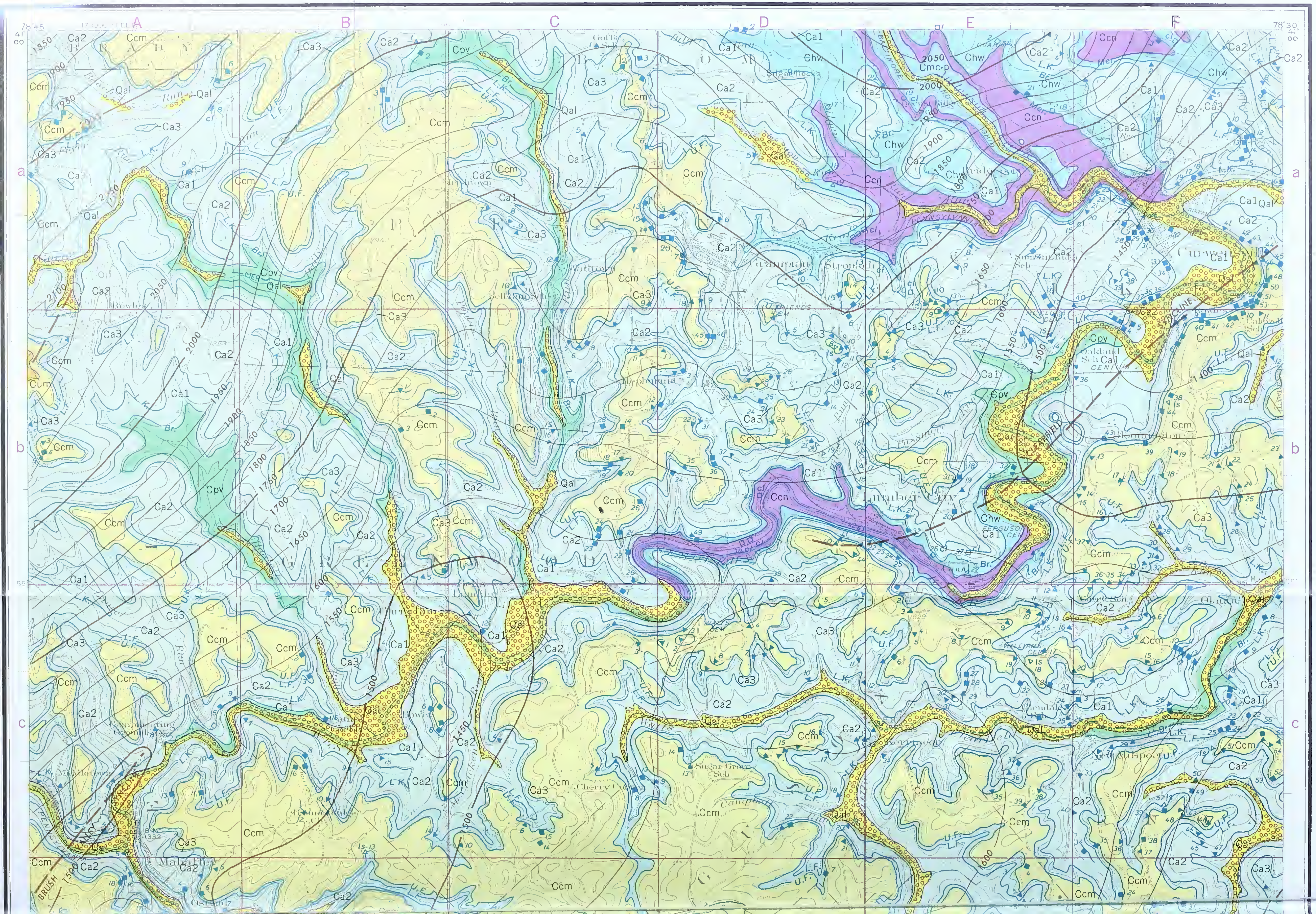
Datum is mean sea level

1939

EPARTMENT OF THE INTERIOR

STATE PLANNING BOARD
IRVING HAND, EXECUTIVE DIRECTOR
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, STATE GEOLOGIST

TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
SHEET 75, CURWENSVILLE AREA, PLATE IV



EXPLANATION

Qal
Alluvium
(in flood plains and valley bottoms)

Ccm
Cum
Conemaugh group
(area of outcrop on the rocks above the Upper Freeport coal. (Cum) Upper Mahoning sandstone

Ca3
Allegheny group
(rocks between top of Upper Freeport coal and base of Lower Freeport coal)

Ca2
Allegheny group
(rocks between the base of the Lower Freeport coal and the base of the Lower Kittanning coal)

Ca1
Allegheny group
(rocks between the bases of the Lower Kittanning and the Brookville coals)

Chw
Cpv
Ccn
Pottsville series
Chw *Homewood ss. with Mercer coal and clay at its base.*
Ccn *Connoquenessing ss.*
Cpv *Pottsville undivided*

Cmc-p
Mauch Chunk and Pocono

COAL AND CLAY

Bkt. — Bakerstown coal
Br. Cr. — Brush Creek coal
U.F. — Upper Freeport coal
L.F. — Lower Freeport coal
U.K. — Upper Kittanning coal
M.K. — Middle Kittanning coal
L.K. — Lower Kittanning coal
Br. — Brookville coal
Mer. — Mercer clay

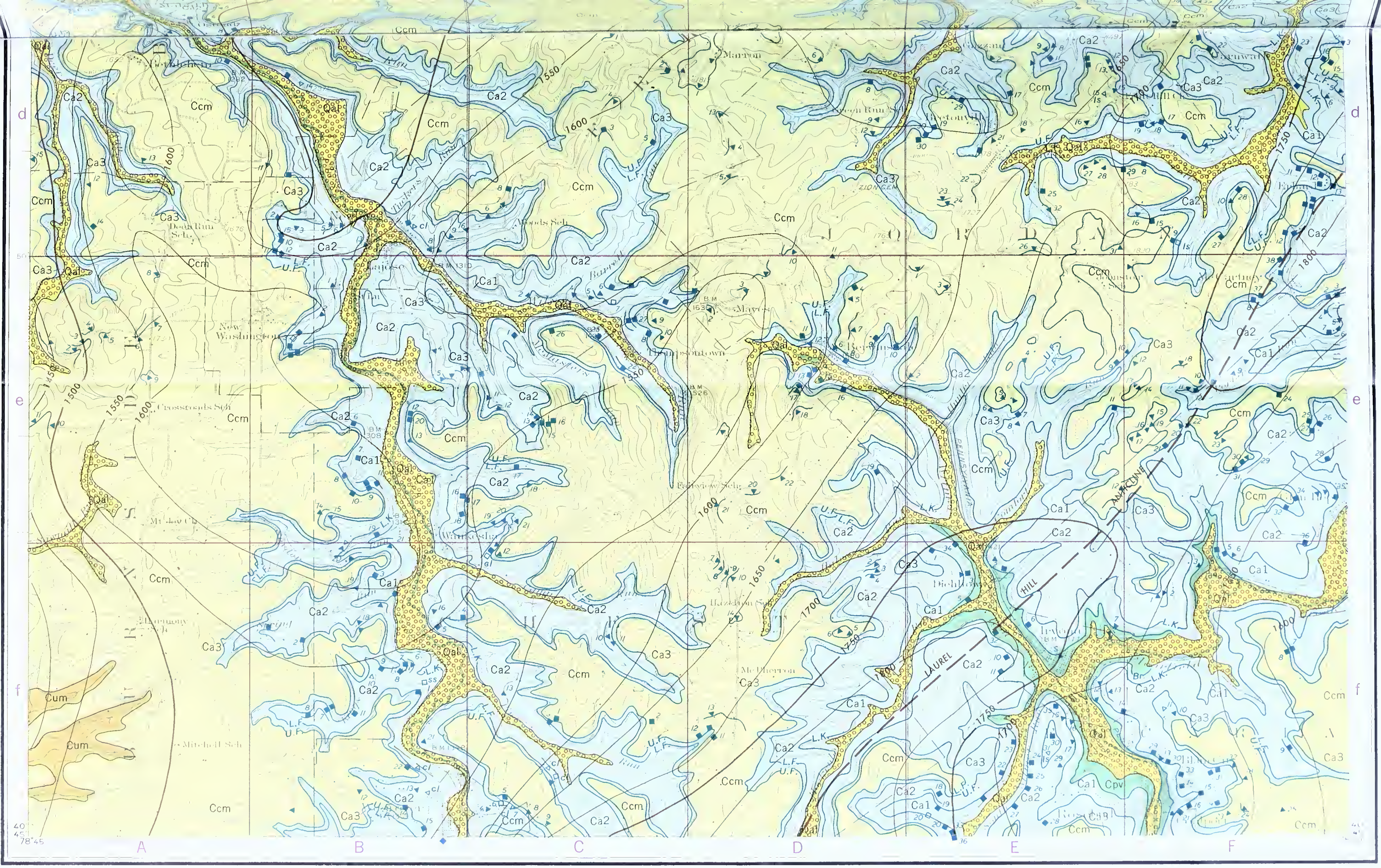
SYMBOLS

— Brookville coal
— Mercer clay

- Coal mine
- Coal outcrop
- cl — Clay mine
- cl — Clay outcrop
- ls — Limestone
- ss — Sandstone

1750

Structure contours on
Upper Freeport coal



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MAP OF THE CURWENSVILLE QUADRANGLE, PENNSYLVANIA

Showing Mineral Resources and Structure

Geology by Geo. H. Ashley, and F. G. Clapp,
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